The Blast Furnace and Steel Plant

The Acid Open Hearth Process

Bringing Bath to Proper Condition Toward the End of the Melting Process and Use of Deoxidizers Discussed—Graphical Representation of Reactions.

By **F. ROGERS, D. Eng., B. A. M. Sc. (Sheffield).**

While numerous writers have dealt with the general metallurgy of the acid open-hearth among the other steel-making processes, they have, on the whole, left room for a reasonable claim that persistent mystery and some ignorance continually enshroud steel making, especially by the acid open hearth and crucible processes.

Many of the views and suggestions in the present paper will have a direct or indirect bearing upon steelmaking by all the six usual processes, but attention has been centerd upon the acid open hearth process, partly for the reason mentioned, and also because for a considerable period of years acid open hearth steel has remained in this country a sort of standard of reference for quality among structural steels. Further, the metallurgy of this process offers in many respects a convenient starting point for the study of all the steel melting processes.

In all the oxidizing processes it is essential at the end to deoxidize the metal by some means. The prime effect of neglect to do so is blowholes in the ingot, a defect which in the majority of cases is inadmissible. There is also considerable evidence which suggests, but as yet does not prove beyond doubt, that beside the gases (mainly oxygen in some form and hydrogen and nitrogen) which cause blowholes, further gas, including oxygen, remains in combination or solution in the steel to its detriment. .

Two principal methods are in use which contribute to secure the desired end. The first is the bringing of the bath to proper "condition" towards the end of the melting process; this factor assumes exceptional importance in the open hearth acid process. The second is the use of deoxidizers.

The term "condition" is often abused in its application to steel melting, being used in a vague and mysterious manner, frequently to cloak ignorance. It is true that it is not yet possible to keep the working under the continuous control of instantaneous precise measurement, but there is every reason why this fundamentally important "condition" should be as fully understood as possible.

What is meant by "the condition of the bath" is, properly its temperature, the composition (particularly the carbon and oxygen contents) of the metal, and the composition (particularly the iron oxide content) of the slag.

There are many considerations involved in judging the "condition" during working. After the primary aim, the adjustment of the carbon content, is well in hand, the deoxidation of the metal should occupy first place. The diminution of oxygen in the metal is indicated by the appearance of the sample and by the quieting down of the reaction, in conjunction with the carbon content of the metal, the composition of the original charge and slag so far as known, and the temperature.

"Dead melting" means the minimizing of oxygen in the metal at this stage. The influence of temperature in dead melting is usually misunderstood. The reaction between iron oxide and carbon in the bath proceeds further in the direction of minimizing the total iron oxide present, as the temperature is raised. On the other hand, the rate of oxidation of the bath by the furnace atmosphere increases with the temperature. In practice, however, under ordinary conditions, the author has found that the balance is strongly in favor of the higher temperature. No satisfactory figure for the temperature can be given, since the means of measurement hitherto available are always open to an error of 20 deg. to 30 deg. C., and this amount is sufficient to make the difference between good dead melting and bad.

Diagram I, with its legend illustrates this point. It has already been mentioned that it is important to minimize the small amount of oxygen which remains in the metal. The foregoing remarks, however, would apply equally well if we were merely contemplating the minimizing of oxygen in the slag, but in some of the following remarks this would not apply, and it may therefore be taken that the author considers oxygen as being present in the bath (and in the solid steel) in small amounts as dissolved iron oxide.

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The bearing of these views, however, is less clear unless it be realized that he considers that when dead melting is achieved, there is an appropriate equilibrium involving the retention of an amount of iron oxide in solution, in the molten metal, which is quite a definite amount in relation to the other factors involved (temperature, carbon principally, in presence of iron, silica principally). The equilibrium here referred to is not a stationary condition, but the reaction still continues, in passing through this condition.

The influence of lime (if present) in this equilibrium, should here again be mentioned for the sake of completeness.*

The addition of lime causes in effect the displacement of some iron oxide (although the entire slag remains an approximately homogenous solution) which reacts with carbon in the metal, thus lessening the total iron oxide in the system. The effect is slightly increased because the distribution of iron oxide between slag and metal will (upon well-understood physical and chemical grounds) be proportioned to the total iron oxide present, that is, the addition of lime does not merely lessen the iron oxide in the slag, but also lessens the iron oxide in the metal correspondingly. The diagram represents this:

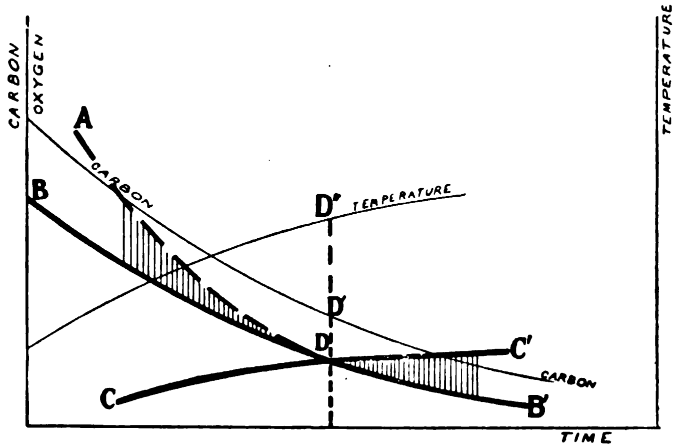

Diagram I—Dead melting.

Curve "Carbon" shows the bath carbon content (C) in relation to the time (t).

Curve "Temperature" shows the corresponding temperatures.

Curve BB' shows the oxygen (O) taking part in the reaction $FeO + C = Fe + CO$; the equation of the curve is $O = -\frac{16}{12}\frac{dC}{dt}$.

Curve CC' shows the oxygen entering the slag from the atmosphere. CC' and BB' intersect at D.

Curve AD shows the total oxygen present in the bath previous to D. The curve AD frequently meets BB' elsewhere than at D.

The part of the ordinate intersected between BB' and ADC' represents the oxygen in the bath in excess of that taking part in the reaction $FeO + C = Fe + CO$. These intercepts are plotted separately in Diagram II.

The ideal consists in dead melting to "condition D," that is:
Oxygen D, all in course of removal by reaction $FeO + C$;
Carbon D';
Temperature D''.

Effect of Adding Lime.

$FeO - SiO_2$	Slag	$\left.\begin{matrix}CaO\\FeO\end{matrix}\right\} - SiO_2$
$FeO - C$	Metal	$FeO - C$
Before adding lime.		After adding lime.

It is evident from this explanation of the action of lime that when, as often happens, the nature of the charge and other conditions are such that the early addition of lime is not essential, it is sufficient to add lime at a late stage, in approaching the dead melted condition. The above-described reaction then occurs, and a satisfactory dead-melted condition is attained in from 20 to 60 minutes, according to various other circumstances. In this way the exposure of the banks to possible damage from careless handling of the lime is minimized.

It is necessary, in considering the above, to realize that the whole process is an oxidizing one, and that the oxidizing action never ceases during normal working. Thus the expression "dead melting" is a relative one, and it is important to inquire what happens if the "dead-melted" condition be over-stepped in any way. At this stage the reaction may be comparatively slight—for example, a drop of 0.01 per cent carbon in ¼ hour—or rapid, a drop of three to five times as much—yet with satisfactory results. Reference to Diagram I. will show what may happen next: We may in the extreme case have the rate of production of iron oxide by furnace atmospheric oxidation greater than the rate of its decomposition by carbon, and the carbon being low, the metal becomes increasingly charged with iron oxide. It is probable that the solubility of iron oxide in the metal increases slightly as the temperature rises and as the carbon decreases beyond some very low figure (Diagram IV).

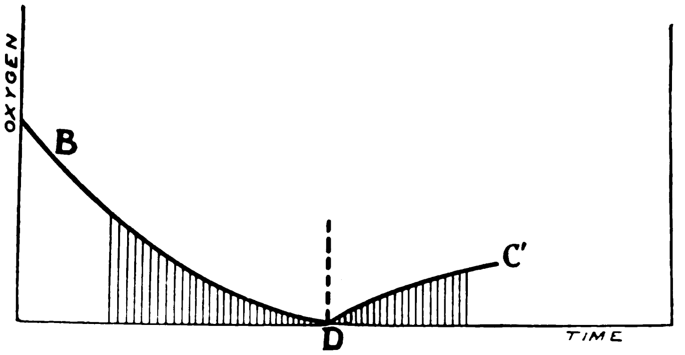

Diagram II—Dead melting.

The ordinates are oxygen in excess of that taking part in the reaction $FeO + C = Fe + CO$, as obtained from, and explained under, Diagram I.

It is further probable that the solubility of each of the gases decreases continuously with rise of temperature from the melting point, but drops suddenly in solidifying, as shown qualitatively in Diagram IV for oxygen as CO.

Reference to Diagram II will now show in a simple form one of the principal features extracted from Diagram I, namely, the curve of excess oxygen present—the oxygen in the bath as a whole which is in excess of what can be removed by the reaction with carbon.

In Diagram III the corresponding complete diagrams (such as Diagram I) for two different temperature curves are given, with summary of several of the most important effects of adopting the higher temperature curve.

We can now see the several conflicting factors which enter into the proper deoxidation at this stage—the chances of under-doing it on the one hand, and leaving the steel considerably oxidized, though not markedly wild (this is the commonest error) or, on the other hand, overdoing it and producing wild steel, which is not in all circumstances fully cured by the use of deoxidizers. Thus, for example, it is useless to make a rigid practice (as the author has known done) of running the carbon down to 0.07-0.09 per cent in all casts, with practically no reference to "condition" in other respects, and then to imagine that this is dead melting because a lot of "pigging-back" was done. At 0.09 per cent carbon the bath is usually "underdone," because a relatively high temperature is required to dead-melt at this carbon.

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* Journal of the Iron and Steel Institute, 1917, No.1, p. 99.

Incidentally, a relatively slight excess of temperature would, under these circumstances, lead to wildness; but with care in approaching 0.09 per cent carbon there is no difficulty in obtaining a good dead-melted condition at this carbon if necessary.

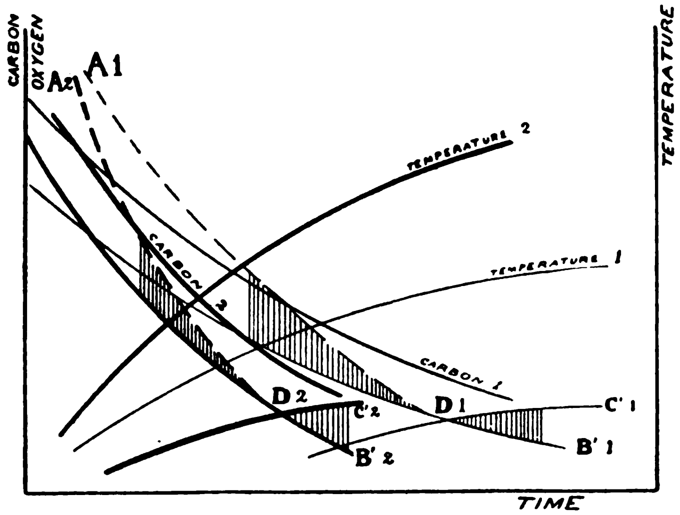

Diagram III—Dead melting. Influence of temperature.

Two diagrams of the type of Diagram I, are obtained for the two different temperature curves 1 and 2. The other corresponding curves are marked throughout respectively 1 and 2. Otherwise the notation is as in Diagram I.

D1 and D2 are the two resulting ideal dead-melting "conditions." The advantages of the higher temperature curve 2 are seen to be; Greater speed of working; greater probability of reaching "condition D" at all; greater definiteness of "condition D," etc., as discussed in the text.

Another extreme instance is the attempt to catch the carbon at say 0.45 per cent carbon, including obtaining three or four successive samples in ½ to 1½ hours, all analyzing 0.45 per cent carbon. This can be done, and sometimes is—approximately—but it is not to be imagined that this is properly "dead-melting." The bath has in such a case been held quiescent by its coldness, and the diagrams show that, under these circumstances, its oxygen content is higher than it should be before going on with the additions. Incidentally, a relatively great excess of temperature, and even a first addition of lime, need not in this instance do worse than cause the fall of the carbon to 0.25 per cent to 0.30 per cent in 1 to 1½ hours and produce a good dead melted bath

It will be realized that to a great extent the diagrams here presented must be only of a qualitative nature. They have, however, been derived from a great variety of experiments arranged to test the various points at issue. It will be seen, for example, that a consequence of Diagram I, as of some of the abobe-expressed conclusions, would be, that if the temperature of the bath could be promptly raised whilst keeping the other conditions (especially oxidation and carbon addition) as stationary as possible, an underdone cast could be dead-melted or a dead-melted cast made wild. This is not, however, very well illustrated in the acid furnace, owing to the relative slowness of the heating, but the action is evidently exactly what should be made fullest possible use of, as mentioned in the foregoing instances. On the other hand, it is possible to study this action in the reverse way—that is, by prompt cooling of the bath. The means by which the author achieved this was the addition of fairly massive scrap steel of similar class to the bath. If this be done when an ideal dead-melted condition has been obtained, then as soon as the scrap addition is melted and mixed in, the bath shows the usual signs of coldness.

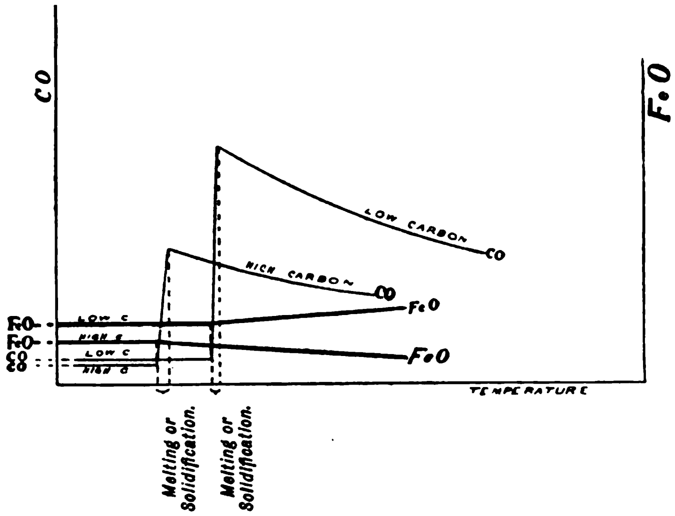

Diagram IV—Solubility of carbon monoxide and ferrous oxide

Again, if a good dead-melted condition be exceeded, and by pushing the temperature too high in relation to the other conditions, somewhat wild bath is obtained, the addition of the correct amount of scrap restores a perfect dead-melted condition.

Here the author feels obliged to issue a word of warning. It must not be imagined that he is advocating the indiscriminate addition of scrap for the control of condition in dead melting; to do so might cause more mischief than it would remove. Further, he does not make a sweeping claim of novelty in adding scrap (or anything else) to the bath, which has often been done by others, especially among the final additions; but he is not aware that it has been used in exactly the way above described in the study of the essential "condition" of the bath. It is one of the most valuable methods of study of which the author is aware, and it has assisted him in arriving at a decision as regards several of the more obscure features of the subject.

It is necessary to draw attention to another important consequence of the above views. In the attempt to end the oxidizing stage satisfactorily, it is from the practical point of view necessary not only to minimize the oxygen present in the system, but also to do so with the carbon content within reasonable limits of a desired figure, which varies considerably with the circumstances. The nature of the running equilibrium has been indicated, and it is therefore evident that some careful choice must be exercised in regard to the controllable excesses which may occur. In this respect we have to notice chiefly temperature, carbon, and iron oxide. The influence of temperature has already been discussed. The important point as regards carbon and iron oxide is to choose correctly the carbon content at which to cease oreing, so that in view of all the particular circumstances then prevailing (approximate ore content of the bath, the relative keenness of working of the furnace, the general nature and volume of the slag, etc.) dead melting will be achieved at a content.

Deoxidizers.

It may be and sometimes is asked: What is the advantage of such great care in deoxidizing the bath by dead melting when deoxidizing additions are afterwards to be used? The reply is that the author has found by wide and careful experiments that no one deoxidizer will alone thoroughly deoxidize steel, and that when two or more deoxidizers are used, each has an effect, and the combined effect is greater than if one of them be omitted; in fact, the more the better, if they be good deoxidizers. The fact that carbon alone is not sufficient to deoxidize steel demonstrates the truth of this conclusion. The actions of the deoxidizers are not quite identical Thus we have carbon, which forms a gaseous product (CO, possibly soluble in the metal, but largely passing off) with the oxygen present, and a soluble carbide with the meta.

Manganese, to the extent it is commonly used, dissolves in the metal in some form and produces manganese oxide, which unites with avidity with silicates, but which is at most slightly soluble in the metal. Incidentally also, a part of the manganese unites with sulphur, producing an insoluble sulphide.

The action of silicon normally resembles that of manganese—it is partly dissolved in some form, and it produces insoluble silica, whose assimilation by the silicates and basic oxides is not so ready as the combination of MnO with the silicates.

Aluminum in the amounts used enters only to a very slight extent into the metal, and produces an oxide which frees itself fairly readily from the metal, but does not readily associate itself with the other non-metallic matters.

From the point of view of partial pressures of solutions and balanced reactions, the greater simultaneous action of deoxidizers seems fairly comprehensible. Despite, for example, the presence of some manganese in the molten metal, a certain amount of FeO and CO still remain dissolved and even unacted upon by Mn.

Upon adding silicon to the system, the saturation pressures of FeO and CO fall still further, but not to zero.

There is similarly a drop upon each deoxidizing addition, assuming that at least a slight excess of deoxidizer is used.

Deoxidizers, Temperature Effect.

The exact saturation pressure of the residual FeO and CO depend upon the temperature. The heat balance shows that in the presence of excess deoxidizer the pressures will fall with higher temperature. This the author has verified in numerous experiments. In other words, the deoxidizers are more efficacious, the higher the temperature of the metal at the time of their addition. The effect of higher temperature and time in giving the entangled products greater opportunities to float to the top is generally recognized. Here again high temperature is advantageous, but it is, as in dead melting, necessary to beware of the renewal of too oxidizing conditions in attempts to raise the temperature at this stage. The casting conditions which have to be met are, however, usually permitted to dictate the temperature control more and more as the end of the process is approched. Throughout, the process is admittedly full of such compromises, but the present is a plea for ideals accompanied by suggestions as to how to attain them, and even in the last-mentioned stage, the author much prefers to see it attempted to get the maximum deoxidation as stated, followed by temperature control, or even by modification in the details of casting, to obtain the required ingots.

Casting.

Approaching the casting stage, the processes have more and more in common, but at the same time there is a greater variety in any event in the conditions to be met, in the size and form of ingot, etc., so that strictly metallurgical generalizations are not so readily applicable to the whole field. Only a few of these points will be touched upon in the present paper whose relation to the melting process proper is closest, and other features will be left until a future occasion.

Much good steel is more or less ruined in "the pit" in casting, and the author has given much importance to the improvement of execution at this stage.

Three of the principal types of original defects in steel are rokes, non-metallic inclusions, and pipe. Rokes which do not contain siliceous matter may arise in mechanical ways in worked steel, but more generally they arise from blowholes in the ingot. The means which have been outlined for minimizing oxygen are the prime means for obviating rokes arising from blowholes. Blowholes, usually local in the ingot (that is, not related to the general anatomy of the ingot) can also arise through wrong design of ingot, bad surface or facing of mould, etc.

Non-metallic inclusions arise in various ways: (1) Entangled slag, and silicates or MnS in suspension in the bath and carried over to the ingot: (2) silicates formed in situ in the ingot by a continuance of the deoxidizing action and aided by oxidation of the steel bv air during passage into the mould; (3) MnS formed in situ by continuance of the action of Mn in the ingot during solidification; (4) fluxed refractory fittings, especially runner bricks.

The influence of high temperature and time in lessening (1) has already been noted. As regards (2) and (3), there is a slight advantage in hot steel; (4) is a strong argument for avoiding bottom running if possible.

Steel made on the lines indicated will have the greatest tendency to piping, but it is always possible to minimize this tendency systematically. This depends essentially upon the adoption of conditions conducive to efficient feeding during solidification. These include the proper proportioning of diameter to length of ingot and means of hindering the cooling of the upper part; these means are of several kinds, and their choice largely depends on cost in relation to the selling value of the steel. Refractory lined heads, and ingots wide end uppermost, are the simplest and most direct methods.

The full advantages of casting ingots wide end up are, for the greater range of ordinary work, best obtained from a mould standing on a loose bottom plate, preferably with a well for sizes over 3 tons or so, containing a loose but fairly massive piece of scrap plate for the stream to strike upon first. If this loose piece be adopted, it is essential that every loose piece absolutely should be identified afterwards for each ingot, since sometimes I have known this plate, if too light, to be washed up into the ingot and cause trouble.

In conclusion, the main object of the present paper have been to give critical consideration to the principal features of the acid open-hearth process which affect the production of a sound, clean ingot. Naturally, attention has been mainly centered upon the most predominant of the features, deoxidation. The means of carrying these principles into effect in the process have been indicated—ideal dead melting and the proper use of lime and of deoxidizers. Finally, brief consideration has been given to conditions which must be observed in order to utilize the full advantage of the high degree of deoxidation obtained, and in order to minimize the piping to which such steel is otherwise subject. It is seen that the author's general preference is for ingots top cast, with the wide end uppermost, and suitably fed, as for example, by refractory heads or special methods.

Resulting Reactions of Superheating Slags

Considerations Concerning the Superheating of Slags and Metals During Refining, Smelting and Alloying Operations. Graphical Representation of These Reactions.

By J. E. FLETCHER, M. I., Mech. E.

I. In the production of wrought iron and steel or ingot iron in the open hearth furnace, it is becoming clearer that the mechanism of refining and alloying is that of the intimate reactions which occur between the various constituents of the pig iron, ore, and scrap charged and those of the slags used in the efficient carrying out of such processes.

The finished cold cast products are crystalline composite masses made up of more or less carbonized or otherwise alloyed crystals separated from each other by boundaries which probably always contain minute particles or films of isolating matter. It is known that such films often contain the iron oxides FeO and Fe_2O_3 together with silicates of iron and manganese. There is further evidence that occluded gases in a fine state of division occur within the crystal boundaries. Such films must tend towards the non-welding of the adjacent crystal faces when the molten or liquido-plastic crystals are being drawn together in their passage to the solid state.

The high temperatures needed in the ferrous alloy processes make the study of the reactions and of the constitutional changes in both slags and alloys exceedingly difficult; there is sense, however, in which it may be said that the reactions at high temperatures are more simple than at lower ones. Thus M. Charpy succeeded in cementing or carbonizing iron filings by heating at 650 deg. C. for about 40 hours in potassium cyanide. the alloy produced being the iron carbon eutectic containing 4.3 per cent carbon and melting at about 1,130 deg. to 1,135 deg. C. Similarly after heating for 85 hours the alloy containing 6.67 per cent carbon and 93.33 per cent iron (Fe_3C) was produced. With only three hours' heating at 1,130 deg. C. the 4.3 per cent carbon eutectic alloy resulted. Moissan, at the temperature of the electric arc, succeeded in carbonizing iron to a content of about 4 per cent in three minutes, and the author, in a like period, also at the temperature of the electric arc, obtained an alloy containing 5.5 per cent carbon. Later Ruff and Goecke produced a 9.6 per cent carbon iron alloy by cementation in an electric furnace at 2,220 deg. C., the time required at this high temperature being relatively short. These experimenters concluded that there

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is a progressive formation of the carbides Fe_3C, Fe_2C, and FeC, at increasing temperatures until at about 2,700 deg. C. gasification of the alloy (FeC + Fe) takes place.

II. The refining and alloying slags in iron and steel processes may be divided into three types. Those having temperatures of formation, fusion, and equilibrium (1st) higher, (2nd) approximately the fusion and equilibrium temperatures of the metallic alloys in contact with the slags.

The slags of type (1) are representative of blast furnace working, where the pig iron fusion temperatures are in the neighborhood of 1,110 deg. C. Such slags have the composition;

$$CaO + MgO + FeO + MnO = 50 \text{ to } 55 \text{ per cent.,}$$
$$SiO_2 + Al_2O_3 + P_2O_5 = 45 \text{ to } 50 \text{ per cent.,}$$

the fusion temperatures of which are in the region of 1,400 deg. C.

The slags of type (2) are typical of the puddling process where the fusion and softening temperatures of the metal being operated upon vary from 1,130 deg. to 1,450 deg. C., the slags having fusion temperatures varying between 1,080 deg. C. and 1,350 C. and being silicates of iron and manganese of the approximate analysis;

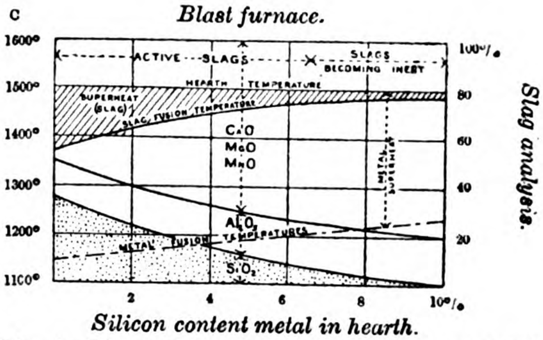

Fig. 1—Illustrating the changes in the composition and temperature of equilibrium during the progressive alloying of a white iron with silicon.

$$FeO + Fe_2O_3 + MnO = 70 \text{ to } 80\%. \quad SiO_2 = 20 \text{ to } 30\%.$$

The slags of type (3) are representative of the open hearth steel melting processes. Here the metal fusion temperatures vary from 1,130 deg. to 1,500 deg. C., while the slags fuse between 1,100 deg. C. and 1,350 deg. C. and have the typical analyses;

$$\left.\begin{aligned} CaO + MgO + FeO + MnO &= 40 \text{ to } 50\% \\ SiO_2 + Al_2O_3 &= 50 \text{ to } 60\% \end{aligned}\right\} \text{(acid process).}$$
$$\left.\begin{aligned} CaO + MgO + FeO + MnO &= 80 \text{ to } 70\% \\ SiO_2 + P_2O_5 &= 20 \text{ to } 30\% \end{aligned}\right\} \text{(basic process).}$$

III. Now obviously the temperatures of refining, smelting, and alloying chambers or hearths of the furnaces being operated must be kept higher than those of the slags or metals under treatment. Hence in case (1) the blast furnace metal is superheated above its fusion point; in (2) the puddled iron and slags may be kept nearly at their proper fusion temperatures, and in (3) the slags are superheated above their fusion temperatures.

Taking as concrete examples the cases cited:

Blast Furnace Slags.

Here the slag fusion temperature is higher than that of the contact metal. The temperatures of the tuyere zone are in the region of 1,500 deg. C., the slag fusion temperatures being between 1,350 deg. C. and 1,450 deg. C., while the underlying metal is melted at roughly 1,140 deg. C. The slag and metal are therefore continuously superheated above their fusion temperatures. The metal in the hearth is primarily of eutectic composition or thereabouts, viz., 4.3 per cent carbon and 95.7 per cent iron.

The result of superheating this eutectic is first to render the contained carbide of iron, Fe_3C, unstable. The higher it is heated above its melting point, 1,130 deg. to 1,135 deg. C., the greater is this instability apparent and its sensitiveness to refining or alloying action increased. Similarly the oxide constituents of the slag which are reducible at the hearth temperature become unstable under conditions of superheat, the silica, SiO_2, and phosphate of lime, $4CaO,P_2O_5$ being readily reducible.

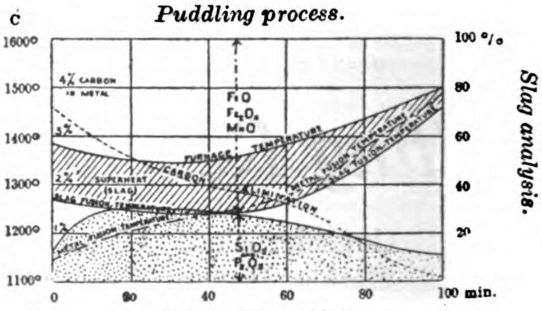

Fig. 2—Action of slags in the puddling process.

At the hearth temperature, 1,500 deg. to 1,600 deg. C., the slag tends to adjust its composition by parting with SiO_2 and P_2O_5 until it attains equilibrium consistent with the degree of superheat. If given sufficient time at, say, 1,500 deg. C., an equilibrium corresponding to the slag composition 20 per cent Al_2O_3, 80 per cent CaO,-MgO would arrive in the case of a smelting using a working slag of primary non-superheated analysis 30 per cent SiO_2, 15 per cent Al_2O_3, 55 per cent CaO, Mgo. The 1,500 deg. C. saturated slag would then be inert, there being no further reducible constituent present in the slag. The metal in contact with the slag would also have moved towards stable equilibrium and it can be shown that in the case of ferro silicon manufacture an alloy composition C 0.5 per cent, Si 9.3 per cent, Fe 90.2 per cent would result when the slag becomes inert. The fusion temperature of resulting slag and metal would be about 1,450 deg. C. (In this case phosphorous, sulphur, and manganese ahve been omitted for the sake of simplicity.)

It is impossible at present to state the composition

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which corresponds to the stable equilibria of slags at varying temperatures or of the metallic alloys in contact therewith, but it may be inferred from the foregoing that by proper adjustment of the primary slag composition it is possible by correct temperature control to regulate the alloy actions in the metal.

It is clear that the cast iron becomes alloyed with silicon and phosphorus at the expense of its carbon the more readily as the slag is superheated and hence free to act on a superheated metal (unstable) in contact with it. Fig. 1 illustrates the changes in the composition and temperature of equilibrium during the progressive alloying of a white iron with silicon. The active and relatively inert conditions of the slag are indicated by the shaded area marked "superheat." The hgher the superheat the more active the slag and the more unstable the metalloid compounds in the metal attacked.

There are, doubtless, cases where, as in certain pneumatic refining processes, the excess of oxygen leads to oxidation of the metal underlying the slag. Such oxides may there rise to the surface and enter the slag which under certain temperature conditions may become more active, increasing the slag superheat because of the addition of iron oxide to the slag and coincidently lowering its fusion point. Carbon in a pig iron charge may thus be oxidized at the expense of iron oxides FeO,Fe_2O_3 in the slag, iron passing back into the metal; such action is coincident with or preceding the silicon or phosphorus transfer. Thus a blast furnace slag may become rich in FeO, the resulting pig iron being white. Iron has then been reduced from the slag in preference to silicon and the total carbon content of the pig iron is lower than in the case where a normal slag free from FeO has been employed.

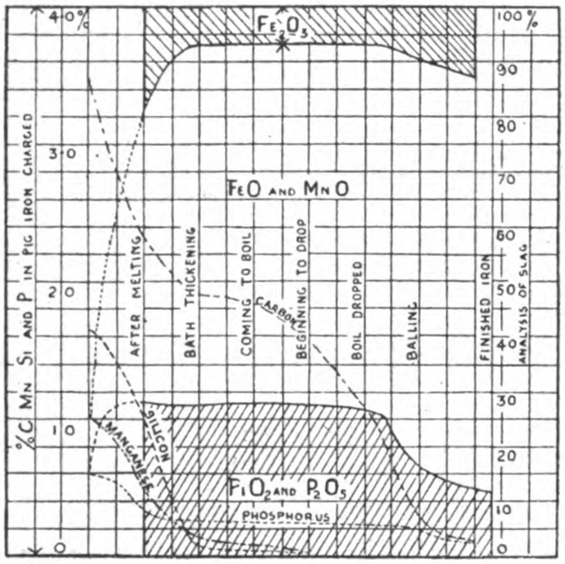


Fig. 3—The progress of refining and the coincident adjustment of slag composition during the complete puddling process, illustrating the effect of superheat on the slag and metal equilibria.

Puddling Slags.

In the puddling process the slags are of the type (FeO,Fe_2O_3,SiO_2) having temperatures of fusion and equilibrium not much different from those of the pig irons which it is desired to refine. Here it is necessary to desiliconize, dephosphorize and decarburize the pig iron underlying or in contact with the slag. The initial fusion temperature of the pig iron to be refined is about 1,140 deg. C., that of the first superposed slag being, say, 1,260 deg. C. This slag is therefore superheated and consequently active. Unlike the blast furnace slag the puddling slag is basic and continues so throughout the process. There is no deterrent or inert constituent such as lime or alumina, hence temperature variations repidly alter the slag constituents. The active iron oxides in the slag attack the unstable iron phosphide and silicide in the pig iron and primarily furnish the oxide for gasifying the unstable carbon in the superheated iron carbon alloy and for oxidizing the silicon and phosphorus which are also but feebly stable at temperatures above 1,100 deg. C. There is an automatic adjustment of the slag composition throughout the process. At the beginning and end of the operation the temperatures are higher than during the intermediate stage. The initial and final slags are therefore high in FeO,Fe_2O_3 and low in SiO_2, whereas in the intermediate stage the slag is more silicous and more readily fusible. During "rash" or careless working the end of the operation is conducted at too high a temperature hence the slag is too highly superheated and adjusts its composition by robbing the iron bath or sponge. The iron oxide thus added to the slag is largely the result of oxidation by the furnace gases (rich in O. and CO_2). Fig. 2 illustrates the forgoing actions. It is seer that the superheat is not so great as in the blast furnace operation. Fig. 3 shows the progress of refining and the coincident adjustment of slag composition during the complete puddling process and illustrates most clearly the effect of superheat on the slag and metal equilibria.

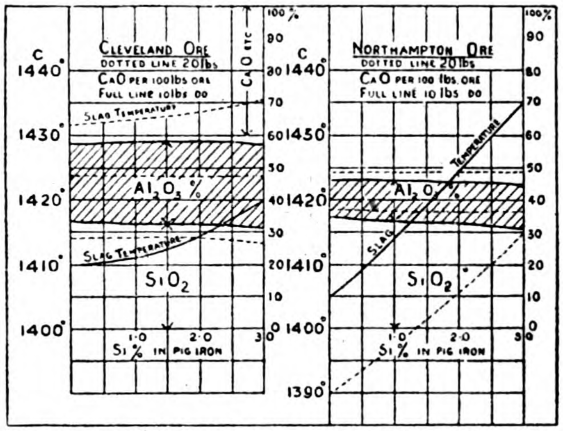


Fig. 4—Automatic adjustment of a typical blast furnace slag (English ore.)

IV. (A) In the production of certain alloy steels the working slags results in the pronounced separation of the most readily reduced slag constituent. Thus in the making of manganese steel in the open hearth furnace the primary slag covering the molten pig iron charge was a rich ferrous slag of the composition approximately $FeO, Fe_2O_3 = 80\%$, $SiO_2 = 20\%$, fusible at about 1,300 deg. C. Into this a pyrolusite ore of analysis $MnO_2 = 85\%$, $CaO,MgO = 5\%$, $SiO_2 = 10\%$, was gradually added. The MnO_2 becomes MnO on superheating, the FeO being changed to Fe_2O_3 by the O liberated from the MnO_2. It was then found that the FeO and Fe_2O_3 in the slag, if increased by further additions of haematite ore (Fe_2O_3) and lime caused a rapid reduction of the Mn from the slag. Mn entering the liquid metal. When the slag contained over 50 per cent Mn then manganese entered the metal whereas if the slag was adjusted so as to contain above 50 per cent of Fe, then iron was reduced from the slag in preference to manganese. An increase in the superheat in either case increased the rapidity of the reduction. The temperature was not measured but it was noticed that the higher MnO slags were more fluid than the rich FeO slags and were apparently fusible at a lower temperature. Hence at the practically constant furnace temperature the high MnO slags were more highly superheated than the high FeO slags, hence more unstable and the Mn in consequence more readily reduced.

TABLE 1.
Typical alloying actions in blast furnace.

	Superheated unstable constituents.				Resulting alloys in metals.				Constituent ejected from metal.	
	In slag.	lb.	In metal.	lb.	Compound	lb.	Free.	lb.	—	lb.
A	SiO_2	60	Fe_3C	360	Fe_2Si	140	Fe	224	CO	56
B	P_2O_5	142	Fe_3C	900	Fe_3P	398	Fe	504	CO	140
C	MnO (1)	213	Fe_3C	180	Mn_3C	177	—	—	FeO	216
D	FeO (2)	216	C	36	—	—	Fe	168	CO	84
					Reactions.					
A	SiO_2	+	$2Fe_3C$	=	Fe_2Si	+	4Fe	+	2CO	
B	P_2O_5	+	$5Fe_3C$	=	$2Fe_3P$	+	9Fe	+	5CO	
C	3MnO	+	Fe_3C	=	Mn_3C			+	3FeO	
D	3FeO	+	3C	=			3Fe	+	3CO	

(B) The refining of alloys may be illustrated in the case of the elimination of manganese in the puddling or open hearth steel processes. Thus the reaction between the slag constituent FeO, Fe_2O_3 and the alloy constituent Mn_3C in the pig iron is of the type;

$$FeO,Fe_2O_3 + Mn_3C = 3MnO + CO + 3Fe.$$

Manganous oxide displaces the iron oxides in the slag, the manganese in the pig iron being replaced by pure iron from the reduction of the iron oxides. Superheating the slag renders the FeO,Fe_2O_3 more active while superheating the molten pig iron increases the instability of the Mn_3C. In the interaction CO gas is liberated. The slag is enriched by the entrance of MnO at the cost of the iron oxides FeO,Fe_2O_3. Professor Turner's view that in such actions the active oxides FeO, Fe_2O_3 are the reducing agents has been taken. They are in the state of least stability and hence in the condition to react with the other unstable compounds present when by superheat their stability is decreased. Possibly at the moment of exchange it is the ferrous oxide which reacts with the Mn_3C in a reversible sense thus:

$$3FeO + Mn_3C \rightleftarrows 3MnO + Fe_3C.$$

Superheating the oxide FeO in an oxidizing atmosphere leads to the formation of Fe_2O_3 (as in the production of "Bulldog slag" by calcining puddling furnace tap cinder). On the other hand liquid Fe_3O_3 when in contact with molten Fe alloys is readily converted to FeO provided a reducing or neutral atmosphere is maintained in working chamber.

Alloying a metallic mass underlying a rich slag. In siliconizing the white eutectic iron in the hearth of the bast furnace the SiO_2 in the slag interacts with the Fe_3C in the carburized white iron in a reaction of the type:

$$SiO_2 + 2Fe_3C = Fe_2Si + 4Fe + 2CO.$$

The carbide of iron in the eutectic metal is displaced by silicide of iron and pure iron is coincdently set free. CO gas is liberated and the slag is impoverished by the silica SiO_2. This exchange is affected by the superheating of the slag, the silicate of lime or magnesia therein becoming unstable. The interaction between the SiO_2 and the unstable superheated Fe_3C is thereby promoted as shown.

(C) Liberation of occluded gases. When cast iron is heated considerably above its melting point the occluded gases, which are not inconsiderable in quantity and consist mainly of CO and H, are set free. An examination of the microstructure of a pig iron which has been thus heated towards its boiling point reveals particles of silica surrounded by an envelope of ferrite together with flakes of coarse graphite. It would appear that a reaction has taken place in this case between the escaping CO gas and the silicide of iron FE_2SI thus:

$$Fe_2Si + 2CO = SiO_2 + 2Fe + 2C.$$

The slaggy particles appearing in the microstructure are probably a silicate of iron formed as per the reaction:

$$Fe_2Si + 3CO = 2FeO,SiO_2 + 3C.$$

In some cases such silicate slag rises to the surface of the metal which has been desiliconized to some extent by gaseous means. Again, sometimes iron oxide particles occur mechanically mixed and distributed throughout the cast iron or steel mass as a result of over-oxidation or over-blowing in the hearth or bath of the furnace or converter. The effect of superheating such an alloy is further to refine the metal thus:

$$FeO,Fe_2O_3 + 2Fe_2Si = 2SiO_2 + 7Fe,$$
$$\text{or } FeO,Fe_2O_3 + Fe_2Si = 2FeO,SiO_2 + 3Fe$$
$$\text{and } FeO,Fe_2O_3 + 4Fe_3C = 15Fe + 4CO.$$

H. Brearley has illustrated this action in his book on case-hardening, where a slag globule is shown surrounded by a ferrite envelope, and generally in iron and steel, slag streaks are associated with adjacent ferrite.

V. The mechanism of refining and alloying through the offices of the slags is shown in the tables Nos. 1 and 2. In the blast furnace a portion of the carbon in the carbide, Fe_3C, is liberated in the CO gas formed and pure iron is freed to unite with the Si and P as silicide of iron, Fe_2Si, and phosphide of iron, Fe_3P. These actions occur when the slag is superheated.

TABLE 2.
Typical refining actions in cupola, open hearth steel, and puddling processes.

	Superheated unstable constituents.				Result of refining, new constituents added.				Gases ejected.	
	In slag.	lb.	In metal.	lb.	To slag.	lb.	To metal.	lb.	—	lb.
A	FeO,Fe_2O_3	232	Fe_2Si	280	SiO_2	120	Fe	392	—	—
B	FeO,Fe_2O_3	232	Mn_3C	177	MnO	213	Fe	168	CO	28
C	FeO,Fe_2O_3	464	Fe_3P	398	P_2O_5 FeO	142 216	Fe	504	—	—

Reactions.

A	FeO,Fe_2O_3	+	$2Fe_2S$	=	$2SiO_2$	+	7Fe		
B	FeO,Fe_2O_3	+	Mn_3C	=	3MnO	+	3Fe	+	CO
C	$2(FeO,Fe_2O_3)$	+	$2Fe_3P$	=	P_2O_5	+	9Fe	+	3FeO

The automatic adjustment of a typical blast furnace slag is shown in Fig. 4, where, during the alloying of the iron in the blast furnace hearth with silicon (the resulting pig irons having 0 to 3.0% silicon),) the slag composition alters thus:

	SiO_2.	Al_2O_3.	CaO, MgO.	Slag softening temp.
	%	%	%	°C.
Before alloying with Si	28.5	20.7	47.1	1,435
With 1% Si in pig iron	28.1	21.5	48.9	1,440
With 2% Si in pig iron	27.5	21.7	49.7	1,440
With 3% Si in pig iron	26.5	22.2	50.3	1,445

As the slag adjusts itself during the loss of Si the fusion temperature of the slag is raised. Hence a higher hearth temperature and resulting slag and metal superheat becomes necessary as the more highly silicious pig irons are made.

Table 2 illustrates the mechanism of refining action in cupola, open hearth, and puddling operations. Here the pig iron being refined is superheated above its melting point, and the silicide, phosphide, and carbide of iron being thereby rendered unstable react with the similarly unstable slag oxides (in this case the iron oxides). Silica and phosphoric acid escape to the slag and CO gas is liberated. The iron set free by the decomposition of the silicide, phosphide, and carbide of iron and that added by deposition from the slag oxides, together with the primary iron crystals in the original pig iron (if containing less than 4.3% carbon) yield a refined product more or less free from silicon, phosphorus, manganese, and carbon.

VI. It is evident from the foregoing that intimate contact between the metal and the slags in smelting, refining, and alloying operations are imperative if successful results are to follow.

In the blast furnace the reduction of the ores must be largely through gaseous (CO) influence. It is not possible for sufficiently uniform carbon (coke) contact with the oxide of iron (Fe_2O_3, etc.) particles to take place. The slag blanket which covers the metal in the hearth of the furnace is agitated by the splashing and penetration of the drops of liquid metal and slag as they descend from the upper portions of the tuyere zone. Hence there is a greater contact between slag and liquid metal than at first appears. The relationship between the area of slag contact and the iron smelted per hour is of practical importance. The ratio:

$$\frac{\text{area of slag contact (sq. ft)}}{\text{iron smelted per hour (tons)}}$$

is, in the case of modern hot blast furnaces 15 to 25. In the days of cold blast furnaces the ratio was as high as 40 sq. ft. of slag contact per ton of iron smelted per hour.

In the foundry cupola the ratio for modern furnaces is 0.7 to 1.0 sq. ft per ton of iron melted per hour, and in the open hearth steel smelting furnaces the ratio:

$$\frac{\text{area of slag contact}}{\text{metal refined per hour}}$$

is 20 to 30. In modern rapid practice in large furnaces the ratio is tending to increase, shallow baths and large area of slag contact being necessary for intensive outputs.

The more viscous and light the slag, the greater is the need for large contact area. During mechanical or natural agitation the heavier slags penetrate the metal surface in direct proportion to their density. In the heavy yet mobile puddling slags the rapidity of the refining action is readily explainable and the low viscosity combined with the continuous hand or mechanical rabbling promotes better contact between the metal and oxide particles.

It can be shown that in the alloying of silicon with iron through contact of the carbide of iron with the silica of the slag, in the blast furnace process, the relative surfaces of contact of these two constituents are as 1 : 1.26 approximately, whereas in the decomposition of Fe_2Si in the refining operation of puddling, the ratio of contact areas between Fe_2Si and the oxides $FeO.Fe_2O_3$ is as 1 : 1. Hence it follows that more homogeneous interactions occur in the latter process. It is interesting to note that the

$$\text{ratio}: \frac{\text{area of slag contact (sq. ft.)}}{\text{metal refined per hour (tons)}}$$

is about 50, twice that of the open hearth steel process, the area of contact being sufficiently large to enable efficient washing and rabbling of the metal and slag to be carried out.

VIII. It is instructive to trace the successive series of iron (liquid crystalline) deposition in the refining processes.

In Table 3 the possible order of iron crystalline deposition is shown in three well-known variations of the open hearth steel making processes.

The first stage of the operation in each case is that of melating the charge. In the liquid thus formed are the primary crystals (melted or as liquid crystals) originally present in the pig iron or steel scrap. The next iron addition to the bath is due to the decomposition of Fe_2Si, the Si entering the sag and ilberating the iron of the silicide, coincidently there being added to the liquid mass free iron reduced from the iron oxides of the slag. Manganese carbide is next attacked by the slag oxides and MnO enters the slag, being displaced by pure iron reduced from the iron oxides in the slag. After this comes the carbon elimination, the carbide Fe_3C on decomposition yielding its Fe to the bath and simultaneously adding pure iron reduced from the iron oxides in the slag. Finally when iron ore (Fe_2O_3) in excess of purely refining requirements is added to the slag, further iron is reduced and makes the final contribution to the mass of refined metal. The analyses and estimates given in the table are only approximate but are believed to offer a comparative view of the order of iron crystallization during refining in the three types of steel making. Whether the iron increments are actually liquid crystals is as yet open to question.

Table 3.

Analyses of materials.	C.	Si.	Mn.	Fe.	Fe_2O_3	SiO_2.	S & P
	%	%	%	%	%	%	
Pig iron	3.8	1.5	0.8	93.9	—	—	not estimated
Steel scrap..	0.2	0.1	0.7	99.0	—	—	——
Ore	—	—	—	—	60.6	10.0	——

Pig and ore process—charge 75% pig 25% ore.

(1) Primary crystals in pig iron = 30.5 initially present in pig iron.
(2) Iron crystals from Fe_2Si decomposition = 4.3 refining of silico-ferrite.
Iron crystals from slag reduction = 3.3 silico-ferrite.
(3) Iron crystals from Mn_3C decomposition = 0.7 refining of eutectic.
(4) Iron crystals from Fe_3C decomposition = 40.0 eutectic.
Iron crystals from slag reduction = 9.6 eutectic.
(5) Iron crystals from ore reduction = 11.6 alloying by iron reduced from ore.

Pig and scrap process—charge 50% pig, 50% steel scrap.

		Per cent
(1)	Primary crystals in pig iron	= 18.5
(2)	Primary crystals in scrap iron	= 44.0
(3)	Crystals from Fe_2Si decomposition	= 2.9
	Crystals from slag reduction	= 1.9
(4)	Crystals from Mn_3 decomposition	= 1.1
(5)	Crystals from Fe_3C decomposition	= 25.6
	Crystals from slag reduction	= 6.0

Pig, scrap and ore process—charge ⅓ of each.

		Per cent
(1)	Primary crystals in pig iron	= 14.6
(2)	Primary crystals in scrap iron	= 34.5
(3)	Crystals from Fe_2Si decomposition	= 2.4
	Crystals from slag reduction	= 1.6
(4)	Crystals from Mn_3C decomposition	= 0.8
(5)	Crystals from Fe_3C decomposition	= 20.0
	Crystals from slag reduction	= 4.9
(6)	Crystals from ore refining	= 20.2

Bessemerized metal low in carbon content and containing considerable quantities of occluded gases and oxide particles is much higher in temperature than the blast furnace metal to which it is added. The superheating action on the latter metal lays the unstable carbon and silicon as carbide and silicide of iron open to a secondary refining action. Some of the graphite is probably oxidized and iron oxide from the Bessemer metal becomes reduced within the mass. The result is a lower carbon iron with smaller nucleus of graphite than is fonnd in hot blast pig irons.

The open-hearth iron, melted and refined under high superheat conditions, unassisted by artificial rabbling and agitation, has a finer crystallization than the puddled iron, which is refined at lower temperatures. This latter action, carried out in a hearth which it itself composed of active reducing oxides, must obviously tend to a coalescence and welding of adjacent iron grains or crystals which is impossible in a bath where the refining action proceeds by way of contact only with a superincumbent slag of low specific gravity and high viscosity. It goes without saying that the question of crystalline metallic structure is inseparably connected with the slag functions. Micrographic analysis cannot reveal the true character of the boundary films, the process of polishing the slag inclusions being altogether unsatisfactory when it is desired to reveal the characteristic structures at high powers of magnification. It would appear to be, therefore, of increasing importance to study the crystalline boundary problem in the light of the foregoing conclusions, bearing in mind the facts that the crystals or crystallites begin to grow in a liquid carrying oxides, slaggy, gaseous, or metallic.

Elements of Roll Pass Design

Rules Presented in Previous Articles Applied in Roll Investigation—Roll Passes Designed to Fill or Slightly Underfill—Bending and Torsion Stresses in Roll Computed.

By W. TRINKS.

The purpose of the present installment is to investigate a given roll, lay out the passes for it in such a way that they just fill, or slightly underfill, and to compute bending and torsion stresses in the roll.

The roll selected for this purpose is a strand roll, shown in Fig. 1. It does not cover latest practice, but that does not matter, because we are here concerned with elementary principles only, and for these the roll of Fig. 1 is very well suited. Strand rolls are usually made of cast iron, very seldom of steel. The stresses will, however, be investigated for both materials.

The dimensions of the roll are clear from the drawing. There are, of course, two additional rolls, like the one shown, used in a three-high mill. The passes are far apart to allow room for the guides. In order not to complicate matters, the distance required between the passes by the guides and guide boxes will not be discussed here, but will be taken as given. Ovals and squares alternate from beginning to end of the roll.

The first step is to compute roughly the strength of the roll. The second step is to lay out the passes in conformity with the first part of the calculation. The third and last step is to figure the strength of the roll more closely on the basis of the information obtained from the second step. In the carrying out of these calculations, some tedious detail work cannot be avoided, but it is hoped that those who are really interested, will take the trouble to follow the calculations.

The preliminary calculation for strength consists in picking out the pass which probably produces greatest bending stress, and the pass that produces greatest twisting stress in the rolls, and in roughly computing the greatest stresses. For that purpose the exact depth of each pass need not be accurately known, because the factor of safety which must be allowed on account of variation of temperature and composition of steel readily takes care of slight changes in diameter. A brief consideration tells us that, in the roll under consideration, either pass (1) or (2) or (3) produces the greatest stress. From pass (4) on, the forces rapidly become smaller and the roll becomes stronger.

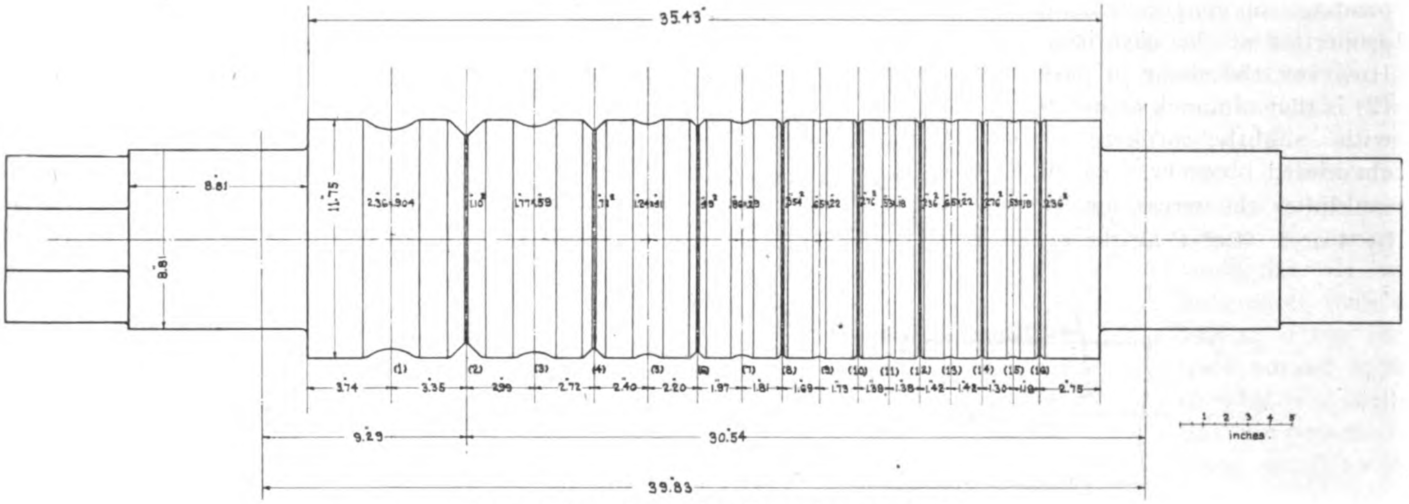


Fig. 1—Dimensions of roll used as example.

For those who may not be familiar with all of the information given in previous installments, it may be mentioned that separating force equals projected con-

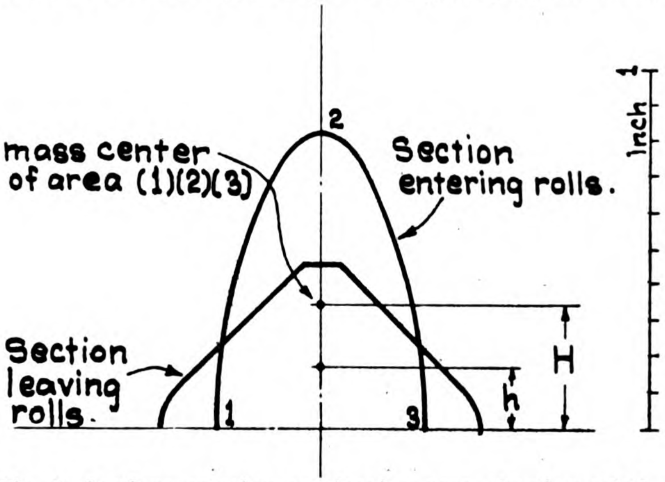


Fig. 2—Sections entering and leaving pass, showing relative deformation.

tact area times pressure between steel and rolls. Beyond pass (3) in this roll the projected area becomes very small, while the pressure increases only slightly.

Detail calculation shows pass (2) to be the weakest as far as bending stresses are concerned. For that reason a sample calculation will now be given for that pass only, although in practice the same calculation must be made also for passes (1) and (3) so as to find out which is the weakest. In the second pass the diameter of the roll at the bottom of the groove is about 10.2 inches, which makes the section modulus for steel equal to 106 in.^{3}. For cast iron the modulus ranges from $1/6\ d^3 = 177.$ up to $1/5\ d^3 = 212$ in.^{3}, depending upon the elastic properties of the cast iron. However, the shape of pass (2) is that of a nick or notch with slightly broken or chamfered corner, which multiplies the stress locally by 4 or 5. Let P be the allowable force tending to separate the rolls; then the allowable bending moment for pass (2) is $M = \frac{9.3 \times 30.5}{39.8} P = 7.11\ P$, where 9.3 inches and 30.5 inches are the distances from pass (2) to the supports of the roll. But the moment equals stress times section modulus, so that we have for cast iron

$$7.11\ P = \frac{25000 \times 180}{5}, \text{ and}$$

$$7.11\ P = \frac{45000 \times 106}{5} \text{ for steel.}$$

From these equations follows:

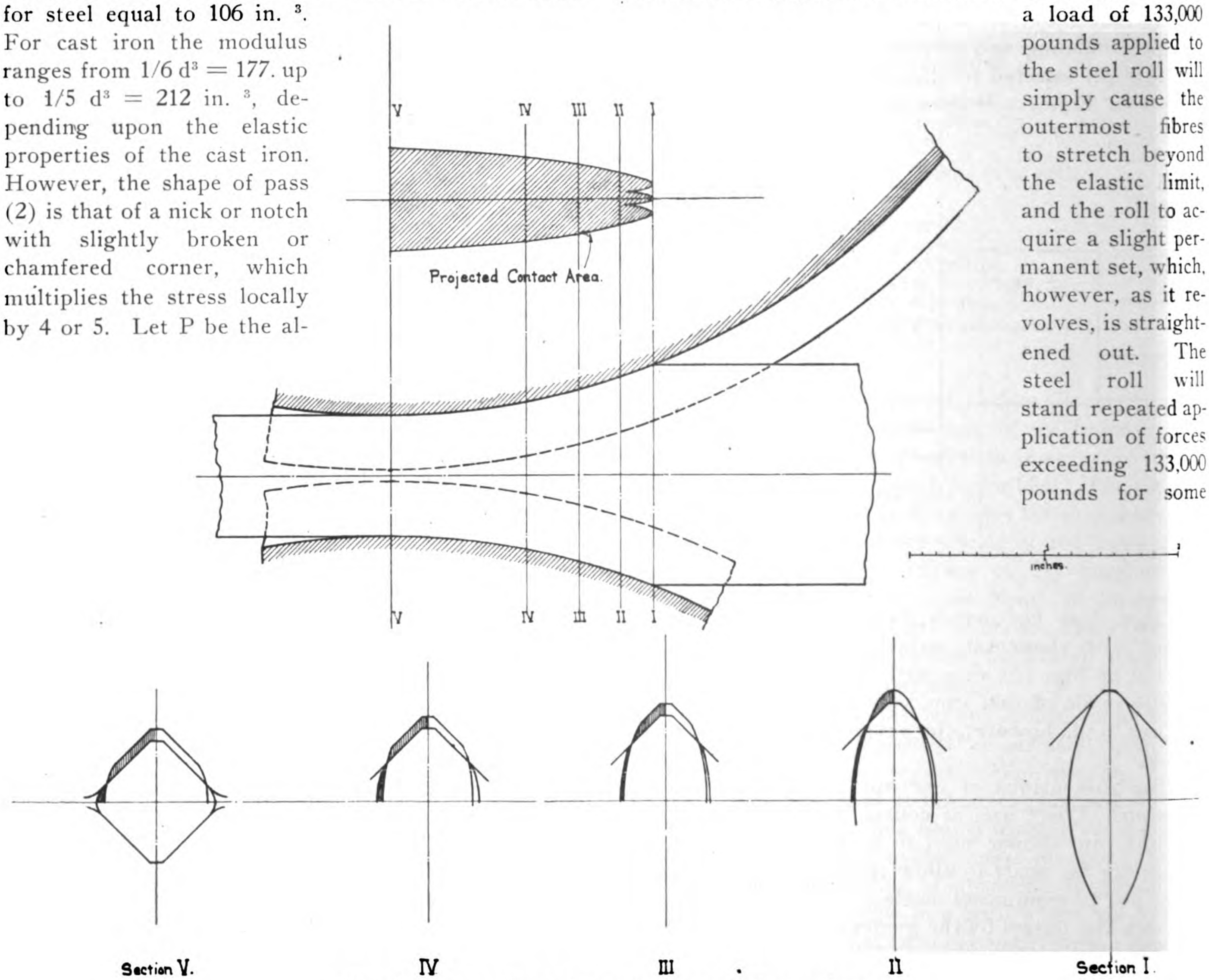


Fig. 3—Square of pass two entering oval of pass three.

In the case of a cast iron roll the force P which will just break the roll equals 125,000 pounds. In the case of a steel roll, the force which will strain the roll beyond the elastic limit is 133,000 pounds. The ultimate strength of the steel roll is, of course, much greater. While the cast iron roll is broken, or at least cracked, by a load of 125,000 pounds applied once, a load of 133,000 pounds applied to the steel roll will simply cause the outermost fibres to stretch beyond the elastic limit, and the roll to acquire a slight permanent set, which, however, as it revolves, is straightened out. The steel roll will stand repeated application of forces exceeding 133,000 pounds for some time, before cracks appear. A factor of safety of three reduces the allowable separating force to 41,700 pounds for cast iron, and to 44,300 pounds for steel.

To ascertain whether or not this force is exceeded in the use of the rolls we must form the product: Projected contact area times pressure between steel and rolls. From Fig. 4 it is apparent that the shape of the projected area for an oval entering a square on edge is roughly parabolic, so that we have area = 2/3 base × height. For pass (2) this becomes projected area = 2/3 × 1.35 × 2.1 = 1.9 square inches. The pressure between the steel and rolls follows from the temperature and from the velocity of deformation. Let the temperature be 2,100 deg. F., which is about right for the second pass. Let the peripheral speed of the roll at center of grip be somewhere between 700 and 1,000 feet per minute, then time T of deformation is about 1/60 second; $\log_e (\frac{H}{h})$ (see Fig. 2) is about equal to $\log_e (2.1) = .74$ so that $\frac{\log_e (H/h)}{T}$ is somewhere between 36 and 50. But for this great rate of deformation the pressure reaches its maximum value of 18,000 pounds per square inch, (see Fig. 1 of November installment). Hence separating force equals 1.9 × 18,000 = 34,200 pounds. This is very near the allowable force of 41,700 pounds, and is close enough not to make any change in the design of the roll.

As before mentioned, the other passes produce smaller stresses in the roll.

In the design of the passes it is usually known from previous experience how to lay out their shape so that they will just fill or slightly underfill. In the present example, the shape of the passes will be assumed and then an analysis will be made to investigate how they fill.

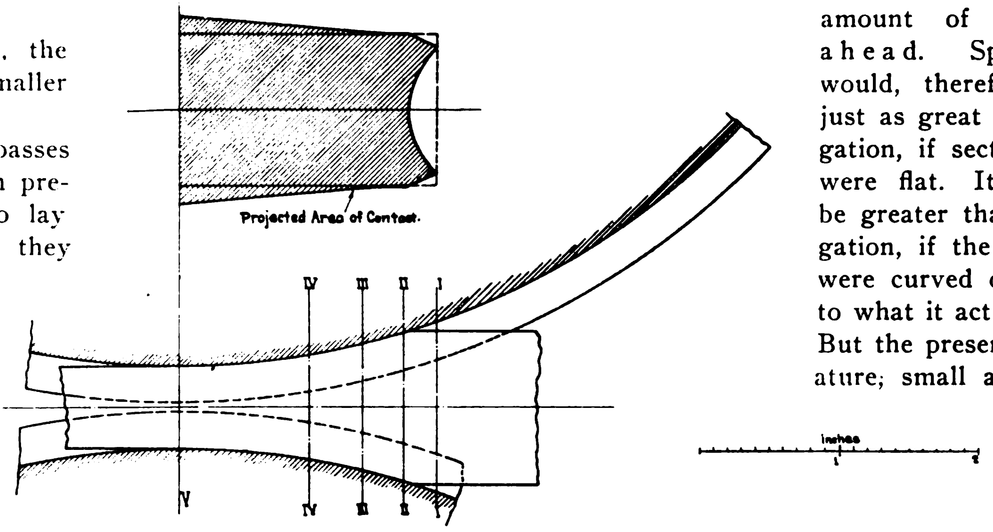


Fig. 3 represents such an investigation, showing how the material is deformed when the square of pass (2) enters into the oval of pass (3). The upper part of the illustration shows the projected contact area; also part of a cross-section through the roll at the pass, with the entering bar. The total draft was divided up into four equal parts, and sections I, II, III, IV and V were made at right angles to the bar through the points of equal draft. These sections through the roll, together with the shape of the bar in the preceding sections form the bottom part of the illustration. In each section the metal displaced by direct squeeze has been section-lined vertically, whereas the metal added by lateral spreading has been section-lined horizontally. In section I the bar just touches the roll. In section (2), some compression has taken place. Since the pass is symmetrical, we need consider ¼ of the pass only (if we abstract from the small difference of diameters between upper and lower rolls which is used to hold the bar against the guard). Then dgef is the displaced area. This area goes partly into elongation and partly into spreading. To decide which percentage goes into one and which into the other, careful judgment must be used, taking care of all the influences explained in previous chapters.

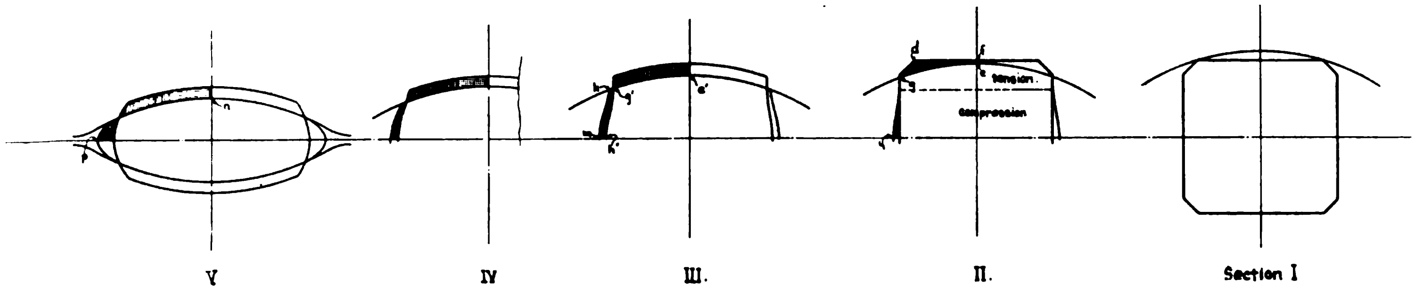


Fig. 4—Oval from third pass entering square fourth pass.

Keeping in mind the fact that material gives way in the direction of least resistance, we must study section II in connection with the plan view of the projected area. Pushing the material ahead is difficult on account of the great amount of friction ahead. Spreading would, therefore, be just as great as elongation, if section (2) were flat. It would be greater than elongation, if the section were curved opposite to what it actually is. But the present curvature, small as it is, somewhat reduces spreading. Another factor must be considered, namely, the distribution of stresses at entrance, between sections I and II. At top and bottom tension occurs, whereas in the center there is compression. Consequently any spreading tendency which might exist in the section marked tension, is counteracted by lateral contraction caused by said tension. This still further reduces spreading. We, therefore, judge that 1/3 of the deformation goes into spread, and 2/3 into elongation. Consequently 1/3 of area dgef was placed on the side of the bar, see curve gh. Spreading is, of course, greatest in the center, because there we have both up and down compression, and front and back compression.

Shape hge is now transferred to section III. Conditions here are very similar to those existing in section II, with the exception that resistance to elongation is somewhat less than at section II. The portion of the deformation going into spreading will, therefore, be 1/3, or a little less than 1/3, say 1/3.5. This fraction of the vertically section-lined area was transferred to the side, care being taken to place a little more in the center (m, h′) than at the top (k, g′) on account of the restraining influence of the curvature. The same process is repeated at sections IV and V. The more we approach the latter section, the smaller is the resistance to elongation, as explained in previous installments, while the resistance to spreading grows on account of the growing influence of the curvature. Hence the spreading ratio was taken to be ¼ in section IV and 1/4.5 in section V. The final shape of the bar is indicated by the curve np, which indicates that the bar does almost, but not quite, fill the pass. The design is correct.

In this investigation the spring of the rolls, due to deflection of roll and housing, has been neglected, for the sake of simplicity of explanation. In practice, it must be taken into consideration.

Fig. 4 illustrates in exactly the same manner, how the bar after leaving pass (3) enters pass (4). From the shape of the projected contact area one may expect a great deal of spreading, but the wedge-shaped grip of the rolls tends to prevent spreading. The following reasoning was used for the different sections: In section II the part lying above the dotted line cannot spread, because it is held together by the wedge grip of the rolls. The part below the dotted line spreads more than it elongates, on account of the shape of the projected contact area. Taking both together we judge that with regard to the whole area, spreading equals elongation. Hence ½ of the vertically section-lined area was added to the side of the bar. In section III the wedge shaped grip which prevents spreading extends farther down, forward resistance decreases, and the width of the section grows. Hence we add 1/3 of the displaced area on the side. In section IV, we have reduced this fraction to ¼. In section V, the wedge shaped grip extends almost all the way down; there is practically no resistance to elongation. Hence there is hardly any spreading. The ratio has been reduced to ⅛.

For the purpose of a final checking calculation for strength, it is found that the projected contact area of pass (2) equals 1.84 square inch. This is so close to the value used in the preliminary calculation that it need not be repeated. There is some torsional stress at pass (2), but it is small compared to the bending stress.

Torsion becomes of importance at the roll neck, and particularly at the wobbler. Using the methods explained in the November issue, we find the torsional stress as follows:

Torsional moment due to deformation of steel in first pass = pressure × projected area × lever arm = 18,000 × 5.6 × (.7 × 3) = 212,000-pound-inches. Roll neck friction work is, in rolls of this kind, from 50 to 70 per cent of the total work, depending upon lubrication; hence total torsional moment will be somewhere between 424,000 and 710,000-pound-inches. With equivalent-strength diameter of wobbler equal to 6.60 inches, the torsional modulus equals 56.5 inches^3. Hence the stress will lie between the limits of 7,500 and 12,500 pounds per square inch. This is quite permissible for steel, but is fairly high for cast iron. If an additional roll is driven through the same wobbler, it should be a lightly-loaded finishing roll only, because the possibility exists of having steel simultaneously in pass (1) of the present roll and in the finishing roll. This coincidence will, of course, raise the stress in the wobbler to a still higher value.

Measuring Air Delivered by a Turbo Blower

Combination of Standard Orifice and Pitot Tube Used for Accurately Measuring Air Delivered from Turbo Blower to Blast Furnace—Static Pressure Measurement Eliminated.

By **THOMAS G. ESTEP, JR.**

When the reciprocating type of compressor is used for furnishing air for blast furnaces, no devices are absolutely necessary for measuring the volume of air delivered. All that is necessary in order to obtain a close approximation of the quantity of air is the displacement of the compressor and the volumetric efficiency. The latter factor is an uncertain one, depending upon the clearance of the compressor, the ratio of compression to supply pressure and the leakage through valves and around the piston. The volumetric efficiency can, however, be estimated very closely and the volume of air delivered by the compressor can be determined accurately enough for all practical purposes. Even if any of the various measuring devices were used in connection with reciprocating compressors, the results would be in error, due to the pulsations in the flow.

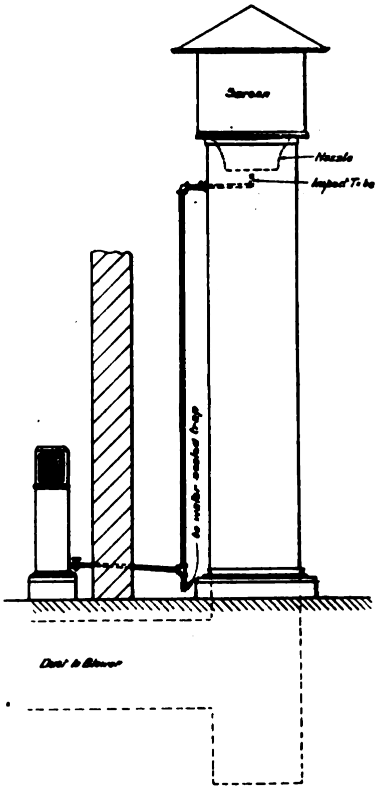
The advent of the turbo blower for furnishing air for blast furnaces has presented a new problem to engineers. It is very essential that the volume of air delivered to the furnace be known at all times and it is even desirable that a continuous record of this quantity be obtained so that a comparative study of the furnace operation can be made.

The blower itself does not give any means of making this determination as does the displacement compressor so that some other means must be employed. Due to the fact that the turbo blower produces a steady flow, any of the approved methods of measuring gases can be used, the only question being to select the most suitable, accuracy and simplicity being the predominating features.

A pitot tube placed in the intake pipe would at once suggest itself as being a simple and accurate means of measuring the volume of air and such installations have been made which are giving uniformly satisfactory results. There are, however, certain factors which must be taken into consideration before such an installation will give reasonably accurate results.

The intake pipe is usually made up of riveted steel plates of which the internal diameter may not be uniform. The ring seams may cause eddy currents which would influence the flow and in certain cases, the intake pipe may be so short that the flow does not become uniform before being measured.

If the intake pipe is long enough and the diameter accurately determined at the point of insertion of the pitot tube and then a traverse of the pipe is made so that the tube can be placed at a point which will indicate average velocity, the quantity of air flowing will be determined accurately enough for all practical purposes.



Showing arrangement of air intake, nozzle impact tube and recording instrument.

The most satisfactory installation seems to be a combination of a standard orifice and a pitot tube. The standard orifice can be placed in the end of the intake pipe, directly under the hood and the pitot tube used to measure the velocity of the air leaving the orifice. Aside from the great accuracy of such an installation, which is of first importance, it has the following advantages:

Practically no changes are required in the intake pipe. The hood may have to be raised a little in order to install the screen and to give a free inlet to the orifice. Some tests made at the laboratories of the Carnegie Institute of Technology showed that if the hood was at least one-fourth the diameter of the pipe away from the orifice it would have no influence on the flow.

The orifice being located in the end of the pipe, the velocity of approach is zero, which means that the chart of the recording mechanism is more easily constructed. If the orifice were placed somewhere in the pipe, it would be necessary to take into consideration the velocity of approach which is an added complication to the calculation of the quantity flowing.

With the orifice located in the end of the pipe, static pressure determinations are not necessary, so that the pitot tube in reality becomes a simple impact tube with just one connection to the recording device. This eliminates entirely the much-discussed question of how to measure static pressure correctly.

The length of the intake pipe has no influence on the measurements.

If the orifice diameter bears the proper relation to the pipe diameter, the loss in pressure is negligible. The orifice itself converts a certain amount of pressure into velocity and then as the fluid issues from the orifice, a transformation from velocity to pressure begins, but due to eddy currents which are produced, not all of the velocity is converted into pressure again.

It is impossible to derive a correct mathematical formula for this loss, but a great many years ago, Carnot proposed an equation for this loss which checks very closely with experimental data. The formula is as follows:

$$\text{Lost head} = \frac{(V_2 - V_1)^2}{2g}$$

Where V_1 = velocity of fluid in pipe, feet per second.
V_2 = velocity of fluid in orifice, feet per second.
g = acceleration due to gravity, feet per second.

The lost head is in feet of the fluid being measured.

Tests were made at the laboratories of the Carnegie Institute of Technology which showed that this equation will give fairly close results. When the velocities are low, the calculated loss is too high and when the velocities are high, the equation gives results too low. Over the range of velocities used in the tests, the variation of the actual and calculated loss did not exceed 7 per cent.

If an orifice diameter of about six-tenths of the pipe diameter is used and the lost head reduced to actual additional horsepower required to drive the turbo-blower, we find that it amounts to less than one-half of one per cent, which is certainly allowable.

Several installations of this kind have been made by the Bacharach Industrial Instrument Company, of Pittsburgh, and are giving excellent satisfaction.

Reinforcing Bars Rolled from Old Rails

Describing the Process of Slitting and Rerolling Old Rails Into Bars to Be Used for Reinforcement—Consideration Being Given to Practical Methods of Rolling and Roll Turning.

By W. S. STANDIFORD.

The use of concrete as a building material has created an extensive demand for steel re-inforcing bars, due to this constant demand a number of mills are engaged in their manufacture. Most mills make their re-inforcing bars out of Bessemer steel. Other things being equal, the steel having the highest elastic limit or yield point, will be the most satisfactory for re-inforcement.

As soon as the elastic limit of any re-inforcing bar is reached, the metal stretches, rapidly decreasing in section, drawing loose from the concrete and destroying the monolithic bond existing before this point is reached. Therefore the safety of the entire structure is indirectly proportioned to the elastic limit of the steel used. The elastic limit of the old rail is 50,000 to 60,000 pounds per square inch, in either twisted or plain bars as compared with an elastic limit of 25,000 to 30,000 pounds for the ordinary bars. From the foregoing, it will readily be seen that re-inforcing bars made from old steel rails with 80,000 pounds minimum tensile strength are far superior for all kinds of concrete work. The rails used to make these bars weigh 1100 pounds per yard, and only the head is rolled, the flange and web generally being used to make small flat steel bars and angles. The rails after long use are sold as scrap by the railroads and can be bought cheaply. An occasional sliver will be found on the surface of the head of the rail, which must be cut off with a cold chisel, as it will not weld in the re-rolling process.

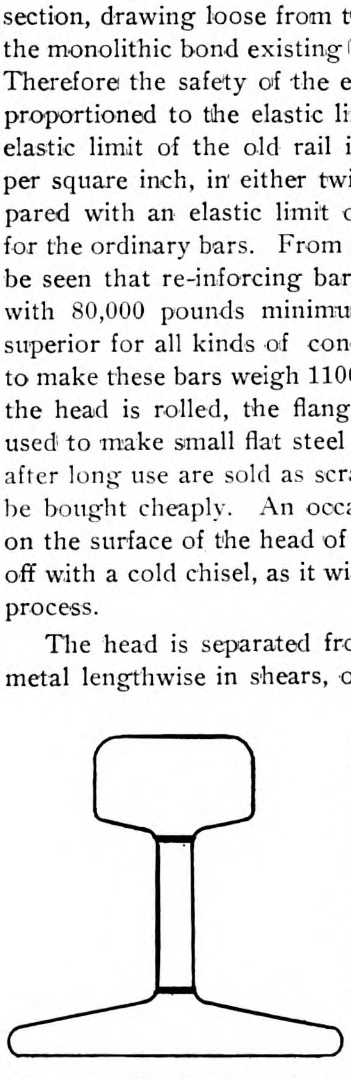


Fig. 1.—Rail showing places where it is to be cut lengthwise.

The head is separated from the web by cutting the metal lengthwise in shears, or cutting the steel while it is hot, in slitting rolls, the head being cut at the fillet, as shown in Figure 1. The illustration also shows where the web and flange are separated, it being customary to remove the flange at the same time so as to save re-handling. In this manner three sets of bars are secured for making different sections. The rail heads are cut into billets of the desired length, put into a heating furnace and evenly heated. (There are two styles of mills used nowadays, continuous and the ordinary guide mills. If the rail head is to be rolled in a continuous mill, it is cut either cold or hot, the whole thing depending upon the ideas of the mill management. Rails can be cut while cold, but it is better practice to slit them while hot, in a slitting mill; as the metal is crystallized and dulls the cutting edges of the cutting knives when they are cut cold. It is necessary for the ordinary guide mill to cut the rail head into such lengths as best suits the furnace designs, which is essentially different from the continuous mill furnace. It is also necessary for the cut rail head billets to be reheated, as guide mills are slower in Figure 2. These rolls are used for breaking down billets of various sizes to make different shaped steel sections. Box and edging passes are put in so as to take a 4x4 inch billet, and reduce it rapidly on account of the heavy draft allowed by these passes. Diamond and oval passes will reduce steel very rapidly and allow heavy drafts, but not for iron at the start of rolling box piles. Inasmuch as iron is not capable of the heavy drafts that steel will stand, most guide mills use box piles or faggots as they are termed. These consist of a square box having sides made out of flat bars, the interior of the box is filled with the ends of round bars, the whole box being bound with wire or band iron. Box passes reduce these piles very rapidly. If they were put into an oval groove at the start, the molten metal between the interstices of the bars squirts out and is wasted, besides many a rougher has lost his eyesight as a result of using this form of pass for iron. This is the reason why most mills in working bars as compared to continuous mills, the billets getting colder quicker in the guide rolls.) They are then ready for rolling in the guide roughing rolls shown use box pass rolls for iron manufacture. For making ⅜ of an inch rounds, iron billets are used at the start, they being reduced rapidly in diamond and oval passes.

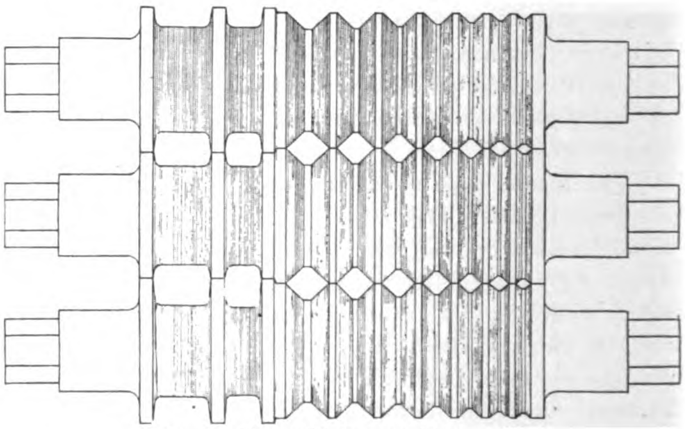


Fig. 2—Three-high roughing rolls.

But even at that the drafts are not as great as steel is capable of standing in diamond and oval passes.

The use of a 4 x 4 inch billet also allows longer finished bars to be delivered by the rolls. Passes of this size are put into guide roughing rolls for this reason, although they are only occasionally used for other orders than concrete bars. The box and edging passes are not used in reducing the rail head billet as the latter is too small in sectional area to enter the latter passes. For the above reason, these passes are not used in reducing the rail head billet, the latter being put into one of the angle passes in the rolls. The 100 pounds per yard rail head billet is about 2½ inches wide across the top and the thickness at the widest part in the center of the head at the cut fillet averages 1⅝ inches. The roughing roll angle passes have angles of 97 degrees with fillets in their bottoms, ranging from ⅜ of an inch wide down to ⅛ of an inch. In the illustration the full number of angle grooves are not shown. The rail head billet is inserted into a suitable angle pass in an upright position, guides being used to prevent it from turning over in the pass. The object of placing the bar in an upright being to force the bar to assume the shape of the pass. This causes it to enter the other grooves more easily. Inasmuch as the bar has a rectangular shape it is necessary to repeat the upright insertions in three different sized grooves, before it can be made to assume the shape of the angle passes in the rolls. This is due to the extreme hardness of the metal in the old rails, thus making light drafts necessary at the start of the rolling.

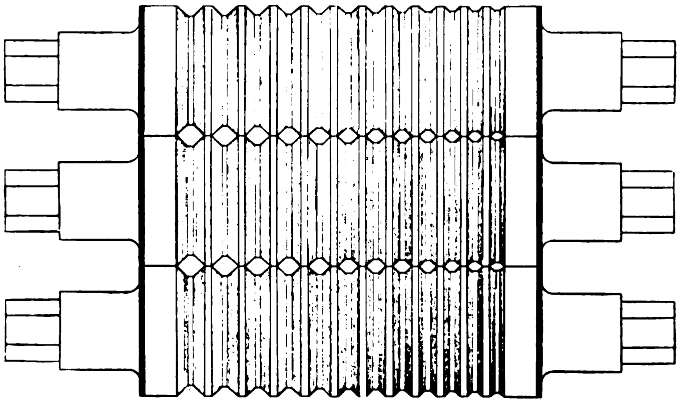


Fig. 3—Strand roll pass layout.

Most oil rail steel after long service changes its structure from a fibrous to a crystalline nature. Rerolling restores the fibrous characteristic, putting it in normal condition again. After the bars go through three passes in an upright position, they assume the shape of the angle passes, this allows the rougher to turn the bars over on the sides, and thus work the part that lies near joints of the rolls. All angle grooves mostly work the bars on the bottoms of the fillets, the object of having fillets in these passes being to work the metal on the corners of the bars as much as possible, there being no work done on the parts of the bar that lie near the joints between the rolls. In both the roughing and strand sets of rolls, the use of fillets in the bottoms of the grooves, compresses the metal on the corners of the bars.

When the bars assume the shape of the angle passes in the roughing rolls, they are turned over on their sides and put through each succeeding smaller pass. They are then ready for the strand rolls illustrated in Figure 3. The passes are more closed in on these chilled iron rolls, their angles being 92 degrees. The fillets are also smaller in order to make sharper corners on the finished square. Diamond grooves are only capable of sustaining a limited amount of draft. When the fillet is too large on the strand bar, the pass area will not be completely filled, and rounded corners will result on the top and bottom of the diamond pass. The steel bar is now transferred from the roughing rolls to the strand ones, and reduced to a 1¼ inch size. The bar is run through the last pass twice, it being turned over at a right angle to its previous position before it is run through the last time. This is done in order to make a perfect square.

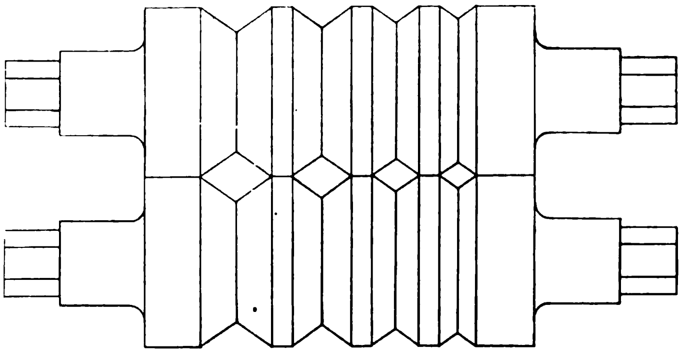


Fig. 4—Diamond roll passes.

If the strand bar were not square in cross-section, the extra metal would squeeze out in the diamond pass at the joints of the rolls, thus the heavy fin would double over and show a lapping mark on the finished square. There is also danger of the collars between the diamond passes breaking out when any pass is overfilled. The writer has seen many roll passes rendered useless by incompetent rollers carelessly setting and handling the rolls. The steel strand bar being rolled to size, is now ready for the diamond rolls shown in Figure 4. These rolls, unlike the roughing and strand rolls, are two-high. It is only necessary to run the strand bars through the diamond pass once. Diamond groove angles vary from 97 degrees to 110 degrees, the variations of different degrees of arcs between the above mentioned angles are used to suit the individual requirements of the mill. The requirements referred to are engine power, methods of heating, the temperature at which the diamond bars are run through the finishing squares, and other local factors, all of which have a most important bearing on the tonnage output of the mill. The grooves commonly

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used and put into the diamond rolls by the roll turner are as follows: ¼, ⅜, ½, 9/16, ⅝, 11/16, ¾, ⅞, 1, 1⅛ inches. Due to the rolls not having a long body length it is customary in some mills to have the smaller sized grooves put into a separate set of rolls. But it is best to have as many different sizes of passes as possible in one set of rolls. This reduces the changing of rolls to a minimum and increases the output. The greatest loss of time in the average rolling mill is due to the frequent changing of rolls.

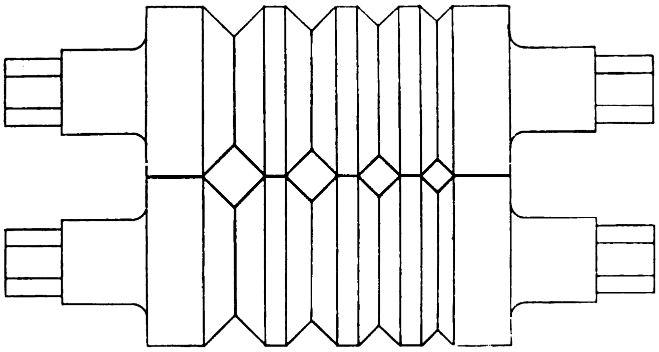
Fig. 5—The square rolls or finishers.

Diamond passes having 104 degree angles are used in forming the square for manufacturing the re-inforced concrete bars. The total width of the diamond bar to make a one-inch square is 1⅝ inches the thickness being 1¼ inches measured over the top and bottom corners of the bar. The size of the diamond bar as given above is subject to slight variations in size of the roller, who raises or lowers the rolls to suit the working of the metal in the rolls, the roller's chief concern is to see that the passes are filled out to their utmost area without overfilling.

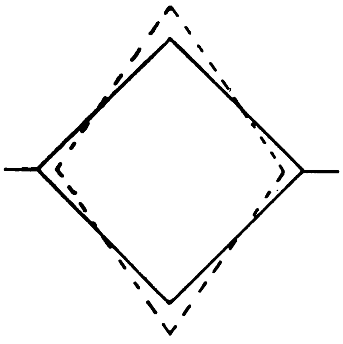
Fig. 6—Position of the diamond bar in the square pass.

The action of the diamond roll groove on the strand bar is very uniform, the strand bar being inserted with two of its square sides facing the top and bottom of the diamond pass, instead of the fillet ends of the strand bar facing downwards towards the sharp edges of the centers of the pass. Of course the strand bar could be inserted in the above mentioned position and still make a good appearing diamond bar. But it is better to place the strand bar with its side facing upwards, instead of a fillet facing towards the bottom of the pass for the following reason: As the bar has been rolled mostly on the angle in the strand passes it is better to change the angle at which the steel is reduced in order to make the metal more fibrous. Hence the advisability of having the strand bar enter the diamond groove in an upright position. It is an axiom of good roll designing, that frequent changing of the rolling position of iron and steel bars in passes makes the metal more fibrous in nature; and the fibrous condition of these metals is what enables them to withstand strains and rough usage.

In the diamond groove, the metal of the strand bar meets the slanting sides of the pass as it is inserted in an upright position, and the flow of the metal is forced toward the center of the pass. This causes an entirely different structural change in metal. As the bar is now near the finishing pass in the square rolls, its elastic limit and tensile strength is very nearly up to the maximum limits of the metal, and the finishing touches are given the bar in the square rolls illustrated in Figure 5. The grooves in these rools have an angle of 90 degrees so that the finished bar will leave the rolls easily without shearing the metal.

By putting square grooves in on an angle, all chances of shearing are avoided, the rolls working very nicely and making an accurate sized bar if the roll turning and roll setting have been carefully done. It is a fact, that no matter how accurately the passes have been cut into the rolls by the roll turner, if the roller is incompetent or careless, he can by his handling of the rolls, make a faulty sized and bad looking bar, the blame of which he naturally puts on the roll turner. The latter if he understands his business, then goes out into the mill and sets the rolls so that they will make good bars. This wastes the roll turner's time, which should be spent in turning rolls and not in the mill doing other people's work. Faulty bars are made by not having the strand pass filled out properly, unequal sized corners on the strand bar; and the diamond pass bar not containing enough metal to make a good square. The square passes in the rolls being crossed (that is when the edges of the passes are not in line with one another) and the temperature at which the diamond and square bars are rolled, also has a most important influence in the making of a good finished product. For instance, if the diamond bar is inserted into the finishing square pass at too high a temperature, the metal being in a very soft condition, will be reduced too rapidly and overfill the pass, spreading out on the collars. If on the other hand, the diamond bar is too cold, it will resist the rolling pressure so strongly that it will not fill out the pass to its fullest area. Should the bar be unevenly heated by the heater, and contain some cold spots on it, the bars will be uneven in size, some parts being larger in diameter than others. This is due to the fact that when the cold spots go through the rolls, the latter spring more than when rolling metal that has been evenly heated. If there are a number of cold spots on the bar, the finished product will be wavy in apearance and size. Thus the important part that even heating plays in the manufacture of steel and iron is evident.

In the square rolls, illustrated in Figure 5, the collars of the rolls are shown as touching one another. In actual practice, the turning of the collars of the rolls are so arranged that the two end collars are 1/64 of an inch larger in diameter than the others, a small amount of light may be seen between the middle collars when the end ones are touching one another. The object of this is to prevent the narrow collars between the passes from breaking out (as chilled iron is a very brittle material) when they slam down on each other after the bar has passed through the rolls. The broad end collars take the shock of the spring. When a bar first enters the rolls, the later spring upwards, due to the wear on the threads of the housing screws, the latter taking to a large extent the shock of each bar as it enters a pass. The spring between a pair of rolls, which is allowed for in the turning of the rolls, is 1/32 of an inch. As the end collars are made 1/64 of an inch larger in diameter than the others, it may be thought that the end passes next to the collars would be lopsided, thus having one side of the square longer than the other. In order to show that this view is erroneous, the methods of turning will be described.

The roll is first faced off level, then the passes are cut in to the correct depth with a tool having a 90 degree angle, dividers being used to make sure that each side of the square is equal in length. After all of the passes are finished, a facing off tool is put in the lathe. This tool is of such length and so placed that its end projects ¼ inch over and on to the end collars. A small shaving of metal is then taken off the collars, thus leaving them all the same diameter with the exception of those portions of the end collars which extend nearest the necks, which are larger in diameter. The 1/64 inch of light between the middle collars of the rolls, added to the 1/32 inch light caused by the spring of the rolls, makes 3/64ths inch open space, which makes the light space between the collars 1/16 inch, this being the amount of distance between the collars of the rolls for a one-inch bar. It is necessary in all cases to have the hot size of the finished square larger in diameter than when it is cold. Now it is evident since the finishing rolls are apart when a bar is passing through, that the two corners of the square at the joints of the rolls would be blunt and rounded in shape if an ordinary strand bar was inserted directly into the square pass. Hence it is found advisable, in practice, to use a diamond shaped bar, and to put the latter into the square groove in a vertical position. This places the sharp corners of the diamond bar in the square groove opposite the joints of the rolls. In Figure 6, the position that the diamond bar occupies in the square pass is represented in dotted outline. It will be observed that the diamond bar does not quite extend to the corners of the square pass, and that it also is actually longer than the distance between the center corners of the square in the top and bottom rolls. The reason for this is the necesstiy of having a sufficient amount of draft on the diamond bar to just fill out the sectional area of the square pass in order to make a good bar. Since the corners on the diamond bar which faces the joints of the square rolls are already made, the change of angle from a diamond to a square keeps the corners of the bar sharp. This makes a perfectly square bar if the roller has used judgment in handling his rolls. When the metal is rolled in the finishing square grooves it flows into the hollow spots, thus forming knobs on the surfaces of the bars.

Physical Analysis of Refractory Material

Available Materials Not Found Wholly Pure—High Tenacity Much Desired Property—Resistance to Corrosion Also Important Feature in Selecting Refractory Materials—Other Discussions.

By **COSMO JOHNS, F. G. S.***

Writers so rarely state exactly what they mean by refractory materials that a definition may not be out of place even though its terms may not find general acceptance. As the metallurgical process employed in the iron and steel industry involve heat exchanges, and high temperatures are necessary for most of the actions that occur, special materials are required for the construction of the portions of the furnaces, ovens, and vessels employed that are exposed to high temperatures and are in contact with the solid liquid and gaseous substances taking part in the reactions. These special materials are refractory if they are capable of fulfilling the structural duties required while subjected to the high temperature necessary for the process employed, and are themselves unaltered during its progress. The conditions that prevail when metallurgical processes are being carried out vary so much, and the problems presented by the occurrence of slags sometimes basic and sometimes acid, of atmospheres now reducing and again oxidizing, call for so many mutually exclusive properties in the refractory material employed, that only an infusible and non-volatile substance, with no volume change during variations of temperature, inert from a chemical standpoint, and with sufficient structural strength yet a non-conductor of heat, would be considered ideal. No such substance is known and very probably does not exist. Hence any refractory materials employed in the metallurgical art will be the nearest approach available to the ideal for the particular process employed. And as metallurgical processes are in practice conducted on commercial lines, the refractory material employed will be that which enables a given unit of final product to be produced at the lowest cost. Fused silica and platinum are useful refractory materials in laboratory experiments, but are excluded from consideration in commercial processes for obvious reasons. In practice, therefore, the refractory material selected is never ideal and always a compromise. The purpose of this communication is to discuss the properties required in any refractory materials employed, to point out their importance with a view to stimulating research, and to invite those familiar with the needs of the iron and steel industry to amplify or correct the suggestions made. It is hoped that any research undertaken can then be applied in the direction most urgently needed and where the most immediate beneficial results can be obtained. At the same time any advances in our scientific knowledge of the properties of available refractory substances, even if not immediately applicable, will be welcome as the foundation of later progress in practice.

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* Presented at the British Iron and Steel Institute, May, 1917.

Available Materials.

With the exception of carbon, and its compounds with silicon, which have a limited application, the available refractory substances are chiefly the oxides SiO_2, Al_2O_3, CaO, MgO, Cr_2O_5, or mixtures of these with oxides of iron, K_2O, Na_2O, and traces of other substances, regarded as impurities, some of which may function as catalysts. The materials available are therefore strictly limited; they never occur in a state of purity in nature. Their manufacture into refractory products involves in many cases sizing, agglomeration or bonding, and final heating to a temperature that varies according to the purpose for which the product is intended and the functions it has to perform. The problems that arise are not solved by a knowledge of the properties of the compounds mentioned; they are complicated by the presence of impurities and the varying nature of the bonding material employed. The final product, as delivered to the user, is always a mineral aggregate, often of great complexity. They possess no fusion point, but rather a range during which softening, at first incipient, at last, with increasing temperature, causes the material to fail to perform its functions. The constituents have varying melting points, and during heating they invert and new phases appear. Some inversions, involving serious volume changes, should be completed during manufacture, but often are not. This is not imputing blame to the manufacturer, for the temperatures required for such changes are rarely known, and even when known as a result of experiments under laboratory conditions, it does not follow that they apply to manufacturing processes. The art has been so long in front of the science of the refractory industry that the most urgent need at present is for an expression, in terms of scientific precision, of the most successful practice in manufacturing the refractory product and of the physico-chemical changes which take place when they are used.

Tenacity and Compressive Strength.

Tenacity and compressive strength at ordinary temperatures are valuable only in so far as they permit the refractory products to be transported and enable them to withstand the structural stresses to which they are exposed when used. This is not difficult to attain. It is when the material is exposed to high temperatures that the value of these properties becomes most important. The abrasion caused by the movement of solid substances while in contact with their heated surfaces is important, while the erosion caused by the passage of dust-laden gases at high velocities becomes serious in time. Little or nothing is known of the conditions that favor or retard abrasion and erosion. High tenacity, which in most cases would mean that of the bonding or of the most fusible constituent, is most probably the desired property. It is the surface exposed to the highest temperature which suffers, for it is the one that is in contact with the moving solids, liquids, or gases. Compressive strength is rarely a cause of failure, for the bulk of the refractory material is at a lower temperature than the face and therefore less affected. There is, however, urgent need for accurate determination of the two properties under discussion at wide ranges of temperature for the more important materials under both oxidizing and reducing conditions.

Corrosion Changes.

Not less important than resistance to high temperature with concurrent abrasion and erosion is resistance to the corrosion caused by slag gases. The effect of acid slags on basic refractories and of basic slags on acid refractories are familiar, while a most striking example might be indicated on the marked corrosion of the silica bricks in the gas ports and uptakes in open hearth furnaces, due to the alternating passage of oxidizing and reducing gases with the resulting formation of fusible silicates. A factor conducive to rapid corrosion in the last case is the absence of large particles of silica in the bricks employed and the presence of excessive pore spaces. Here again little has been published and few observations recorded. The effect of the alkalies found in certain coals on the refractories used in coke-oven construction is serious, and here too little is known as to the real nature of the destructive influences at work.

Volume Changes.

Every element or compound used as a refractory undergoes changes in volume during heating and cooling. Apart from the fact that these volume changes may, and do at times, cause disintegration with the consequent lessening of the useful life of the material, abnormal expansion causes structural difficulties, while contraction may be even more undesirable, permitting the passage of gases from one part of the furnace to another. In the case of coke-ovens the retention of gas-tight partitions is absolutely necessary, and this involves the use of a refractory material which does not undergo appreciable volume changes. This apparent contradiction of the first statement simply means that a mixture of substances with volume changes of opposite sign are employed, viz.: clay and silica. But while the contraction of the burnt clay is fairly regular with increased temperatures, quartz, which is the form of silica found associated with it in nature, has an inversion point at which it becomes trydimite. In the presence of certain compounds this inversion takes place at a temperature lower than that at which coking is carried on. In their absence the inversion is retarded and does not take place until a temperature higher than that usual in coking practice is attained.

Heat Conductivity.

If the refractory material used possess a fusion point or softening range higher than the maximum temperature to which they are exposed, it would in most instances be desirable that they should be non-conductors of heat, for radiation losses would then be at a minimum. More often the prevailing temperatures approach and sometimes exceed that at which fusion or softening occurs. In those cases it is necessary to encourage radiation from the surface farthest removed from the heated surface, in order to cause a steep temperature gradient from the heated to the cooler face. In special cases cooling devices are necessary to prevent the rapid destruction of the material employed. Good conductivity for heat is most desirable where the material is used to form walls which transmit heat from the burning fuel to the contained charge which is being heated. The melting of steel in crucibles and the coking of coal are instances where a refractory material with good heat conductivity is required.

Texture and Porosity.

These physical characteristics of refractory materials determine in large measure their suitability or otherwise for particular duties. Owing to the complex nature of most of the materials used in practice their properties are not those of the simple minerals of which they are composed, but the resultant of variations which are sometimes of opposite sign and are always varying at different rates. The relative size of the grains employed, the extent of the surface exposed by the more resistant constituents to the others used as bond or matrix; are most important factors in contributing to the ability of the material to perform useful service. Another point of some importance is the influence of mass in promoting or retarding inversions. Some of these inversions take place almost instantly once the critical temperature has been reached, but with others marked hysteresis occurs. Porosity must always occur when the refractory material is composed of more than one constituent, and where their chief volume changes are dissimilar or occur at different temperatures. Little is known of the effect of porosity on the properties of refractory materials. That the pores encourage the deposition of extraneous substances in the interior of the bricks, and that they render the structure permeable to gases, is of course obvious.

Stresses Caused by Temperature Changes.

The stresses caused by temperature changes are due to the volume changes which take place during heating. If the refractory material happens to be a good conductor of heat these are not serious, unless one face is rapidly heated and the distortion produced exceeds the tenacity of the material. The remedy available is to avoid rapid temperature changes, and whenever possible to raise the temperature of the material during the burning stage of manufacture well above that at which the inversion to which the principal volume change should take place, and to hold it at that temperature long enough for the inversion to be completed. The "spalling" of magnesite bricks which sometimes occurs has been thus explained, and it is certain that the excessive expansion of silica bricks would be avoided if the manufacturer could insure the completion of the quartz-trydimite inversion during burning. Despite the considerable advances in our knowledge of the inversions of silica made recently, their bearing on the problems that face the manufacturer are not yet sufficiently clear.

Need for Further Research.

Advances in the art of metallurgy are largely conditioned by the nature of the refractory materials available. The manufacture of these materials is based almost entirely on empirical rules and the experience of the men employed. Such rules are the result of experiences gained during a century or more by a rude process of trial and error, but where there were but very inadequate means of correlation. The methods employed to-day represent the survival of the fittest by the searching test of commercial success, but it by no means follows that they represent the best attainable. Further progress, if made at all, can only be slow and uncertain, and by consent it is now admitted that only by adequate and well-directed scientific research can such progress be accelerated. The first step—and in all probability the one easiest to take—would be to prepare specifications for the most important refractory products expressed in terms capable of precise measurement or description, basing the specification on the best current practice. This would only be following the excellent example of the gas industry. But specifications at their best only serve to stereotype the best current practice of their day. These specifications should be the starting point of systematic research which should cover, not only the problems that occur during manufacture, but the occurrence in nature and characteristics of the raw materials. Their concentration and purification, proximate and ultimate analysis, mineralogical description and thermal analysis are all points on which additions to our present knowledge would be of great value. But the refractory materials are so complex, and the problems involved are so difficult of direct attack, that any contributions to our knowledge of the properties of the pure minerals, or of the impure aggregates which are used in practice, would be welcomed even if their immediate application did not happen to be possible.

Electrical Reversing Blooming Mills

Operation of Two Electrical Reversing Mills Compared—Data Concerning Tonnage and K. W. Hrs. Per Ton—Complete Description of Units.

By RALPH D. NYE.

The operation of reversing rolling mills by means of electrical drive is a subject to which considerable attention has been given during the past five or six years in this country. No doubt the electrical engineers are familiar with the scheme of drive, employing the Ilgner system of control which has been used in a number of cases. The questions which are of particular interest to anyone connected with steel plant operation generally relate to details of construction and the reliability, efficiency, and ease of handling of an equipment. Therefore some data pertaining to and the results which have been secured from two typical installations may be of interest. We will refer to these as the number one and the number two equipments.

The Number One Equipment.

The mill in this case is classed as a 34-in. bloomer that is the mill pinions of 34-in. in diameter. The main rolls are 24-in. diameter and 84-in. long. This installation was laid out to roll a maximum capacity of 50 tons of ingots, size 18 x 20 in. and weighing about 5,500 lbs., per hour, to finished billets averaging 4 x 4 inches and using 21 to 23 passes. The estimated power consumption with a mill rolling at an average rate of 40 tons of ingots per hour to 4 x 4 billets was 21 killowatt-hours per ton of ingot rolled.

This equipment consists of the following:

One reversing motor having a single armature 144-in. in diameter. 700 volts d-c., maximum torque capacity 670,000 foot-pounds. Full field speed 47 r.p.m., maximum speed with weakened field about 100 r.p.m. Motor is equipped with 24 poles having a compensating winding and also commutating poles. This machine is separately excited by two field windings, one operated from a constant potential exciter and the other from variable potential exciter. It is arranged for forced ventilation.

One flywheel type motor-generator set made up of:

1—1,500 horsepower induction motor, wound-rotor type, three-phase 2,200 volts. 60 cycle, 20 poles, full-load speed 350 r.p.m. This motor is controlled by an automatic liquid slip regulator. This regulator is operated by a torque motor supplied by current from a series transformer in the 1,500 horsepower motor primary circuit. Regulator is arranged with counterbalance weights, so that adjustment may be made for the torque motor to cut resistance into the 1,500 horsepower motor secondary circuit at any desired current value within a wide range. This is generally adjusted so that resistance begins to come in at about full-load current, and thus slow down the 1,500 horsepower motor and allow the flywheel to take some of the load.

1—60,000 pound cast-steel flywheel, 15 feet 5 inches, in diameter.

1—Generator 1,960 kilowatts continuous rating, 700 volts d-c separately excited field having 14 poles, which are equipped with compensating winding, and commutating poles.

One motor-driven exciter set having two exciter-generators:

One generator is operated at constant potential, 125 volts direct-current, 25 kilowatts capacity and is used to excite the main generator and the constant potential field on the reversing motor. The generator is operated with a variable potential, since its field circuit is excited by the current flowing in the main circuit to the reversing motor. This generator excites the variable potential field winding on the reversing motor. The excitation from this variable potential exciter being proportional to the main current produces a compounding effect in the reversing motor and causes it to slow down under heavy loads. The variable potential exciter voltage ranges from zero to about 125 volts.

One magnet switch group controls the reversing

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motor. This group is handled by a drum-type master controller arranged to give 16 speeds in each direction. Automatic acceleration is secured by interlocking circuits and relays arranged to limit the current input to reversing motor.

The arrangement of control switches and main circuits is shown in Fig. 1.

This equipment was installed in the spring of 1915 and rolled its first steel during June of that year. The first ingots put into the mill were rolled down to a finished size 4 x 4. The mill has practically been in continuous operation since that time, and the total delay due to trouble with the electrical drive since the mill was started does not exceed 10 hours. Some alterations were found advisable in the arrangement of control switches and on the reversing motor since installation. The number of accelerating switches was reduced and some changes were made in relays in order to increase rate of acceleration and speed up operation. On the motor it was found that the commutating pole coils were apt to work loose due to the heavy pulls on them at times of motor reversal, and additional fastenings were added to these coils. Also the interpoles were re-adjusted to prevent any movement under these stresses. The motor commutator was not under-cut at first and it was found advisable to do this to improve commutation. After under-cutting, a type of brush designed for under-cut commutators was installed so that the high current peaks are handled successfully without blackening the commutator.

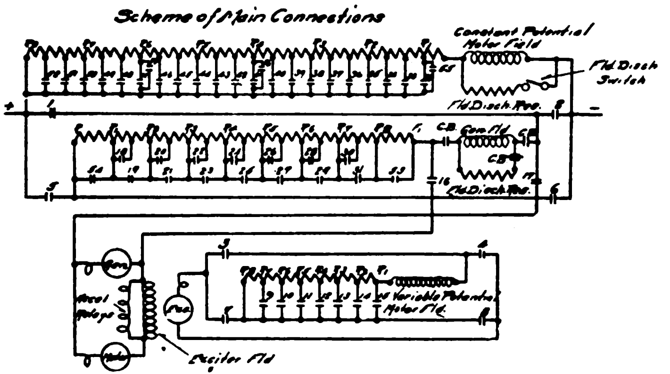

Fig. 1.

Since the motor requires forced ventilation, it is necessary to arrange for a good supply of clean, cool air. In this case air is taken from outside the building through a duct about 40 feet above the mill floor, and is not washed. No trouble from dirt collecting in the motor has been experienced. Of course it is necessary to blow out the machine with compressed air and clean it about once a month. Twenty thousand cubic feet of air per minute, at 1½ ounces pressure is required to cool the motor, two fans of this capacity being provided, both of which are operated in hot weather.

All bearings on the equipment are provided with oil-ring lubrication. The two main bearings carrying the flywheel are operated water cooled.

These bearings and also the reversing motor bearings are arranged for forced oil feed but the equipment is being run without this. The forced feed is considered an extra safeguard against bearing trouble. Neither water cooling nor forced feed has been found necessary on the main motor bearings. It was at first thought that on account of the relatively low speed and frequent reversal of this motor, the rings would not deliver enough oil, but experience shows that they do the work satisfactorily. Each motor bearing is equipped with four rings.

As an indication of the severe service that is put on this type of equipment, it may be said that at two different times the motor has twisted off a cast steel connecting spindle used to couple the motor to the pinion housings. This spindle is about 19 inches in diameter. The main motor bearing next to the pinion housing is provided with a thrust collar designed to take up any thrust due to diagonal breaking of this spindle, and in neither of the cases was any damage done to the motor.

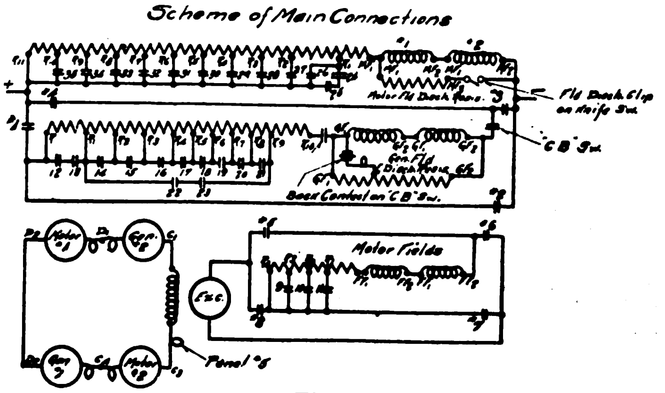

Fig. 2.

As to the rolling capacity of the mill, and the cost of operating the electric equipment, the following table shows the total tonnage of ingots rolled and the actual kw-hour consumption per ton for several typical months' rolling. This includes all necessary power, such as exciter and motor driven fan requirements, in addition to the main power supply.

Month	Monthly Tonnage	Kw-hrs. per Ton
1	21,100	17.7
2	19,400	18.4
3	21,200	18.6
4	18,800	20.6
5	22,100	18.5
6	20,000	24.6
7	21,800	19.5
—		
Average	20,600	19.7

The above tonnage is made up almost entirely of ingots 20 x 22 inches about 70 inches long. Fifty per cent of these were rolled down to 4 x 4 inch billets using 19 to 21 passes. The balance were rolled to a size 6 x 8 inches, using 17 to 19 passes. Approximately 90 per cent of this steel may be classed as high carbon. During the sixth month where a consumption of 24 kw-hrs per ton is shown, a number of new rollers were breaking in on the mill, and this is thought to account for the increase of about 25 per cent above the average in power consumption. No exact cost of attendance of repairs is available, but this item is relatively small and would not exceed 15 per cent of the power cost. The equipment is installed in a main substation where an attendant is required on the switchboard and as he also looks after the mill drive only a part of this attendance cost can be charged to the cost of rolling. The only repairs so far have consisted of brushes and switch contact renewals, the cost of which is relatively small.

The Number Two Equipment.

The mill in this case is a reversing bloomer having 35 inch diameter pinions. This mill is of heavier construction all the way through than the one above, being about as heavy as the average 40 inch bloomer. The rolls are 32 inch diameter and 90 inches long. This mill was expected to roll a maximum capacity of 75 to 90 tons of ingots, size of ingot 20 x 21 inches weighing 7,000 lbs. each, per hour, to finished billets averaging 4 x 4 inches and using 19 to 21 passes. The power consumption with the mill rolling at an average rate of 75 tons per hour to 4 x 4 billets was estimated as 28 kw-hrs. per ton.

The driving equipment in this case consists of:

One reversing motor having two armatures, mounted on common shaft, each 144 inches in diameter, 600 volts d.-c., maximum torque capacity 600,000 foot-lbs. This gives the motor a total maximum rating of 1,200,000 feet-lbs. The full field speed is 40 r.p.m. and the maximum speed with weakened field 120 to 130 r.p.m. Field windings consist of variable and constant potential excited circuits arranged on 24 poles. Machines are equipped with compensating windings and commutating poles.

One fly wheel type motor generator set made up of:

1—2,500 horsepower induction motor, wound-rotor type, three phase 2,200 volts, 60 cycle, 20 poles, full-load speed 350 r.p.m. This motor is controlled by automatic liquid slip regulator as described above.

The flywheel consists of two sections each being 50,000 lbs., cast steel wheel 14 feet 9 inches in diameter.

Two generators each rated 1,450 kw. continuous capacity, 600 volts, d-c., separately excited, 10 poles, equipped with compensating windings, and having commutating poles.

One motor-driven motor exciter set having a constant potential 50 kw., 250 volts, d-c. exciter generator and a variable-potential generator 18 kw. giving maximum potential about 300 volts.

One magnet switch control equipment arranged for automatic handling of the equipment and operated by a drum type master controller giving 16 speed points in each direction.

The arrangement of control switches and main circuits is shown by diagram herewith, Fig. 2.

This equipment was erected during the fall of 1916 and started to roll steel in December. No trouble with the drive was experienced in starting rolling. The usual adjustments of relays and resistance necessary to make the equipment perform in the best manner being all that were necessary. The control equipment is operating as originally installed. The only mechanical adjustments necessary were to scrape in two of the bearings on the flywheel set. Since starting, only one delay, and that about half an hour has occurred. This happened during the time the floor was being put down in sub-station, dust causing the brushes to stick in holders on one of the generators. It was found advisable to undercut the motor commutators and this has been done, giving considerable improvement in commutation. This motor requires about 35,000 cu. ft. of cooling air per min. Two fans of this capacity are installed, one is held in reserve as a spare except in very hot weather when both are operated together. The air supply is taken from outside the substation building and is not washed. No trouble from dust collecting in motor has been experienced except that it is necessary to blow it out about once a month. Rolling conditions are such that additional cooling to be secured from washed air is not necessary.

All the bearings of this equipment are arranged with oil ring lubrication. Cooling water is used on the two flywheel bearings. It was found advisable to put forced oil feed on all the five bearings of the motor generator set in addition to the oil ring lubrication. The motor bearings did not require it for regular operation but it was provided as an emergency measure.

The following table shows the monthly tonnage rolled since this mill was started, and the total kw-hrs. consumption per ton of ingot:

Month	Monthly Tonnage	Kw-hrs. per Ton
1	15,000	33.5
2	14,800	32
3	19,000	30.5
4	21,000	28.5
5	25,000	27
6	22,000	26.7
Average	19,500	29.7

The above tonnage consists of ingots 19 and 21 inches, weighing 6,000 lbs. each. Seventy per cent of these were rolled to 4 x 4 inch billets using 23 to 25 passes. The balance were rolled to a size averaging about 6 x 6 inches and using 19 to 21 passes. Sixty per cent of this steel may be classed as high carbon. The gradual reduction in power consumption per ton from month to month is no doubt due more to expert handling of the mill and also the increased rate of rolling. The electrical equipment is installed in a sub-station having the switchboards, rotaries and transformers and the attendance consists of one operator on each turn with a heper or clean-up man on day turn. The attendance costs chargeable to the blooming mill is not more than 1 per cent per ton of ingot rolled. No repairs except a few brushes and switch contacts have as yet been required.

Without going into the electrical conditions existing in these equipments it is safe to say that the operating results secured have justified their installation. Considered from the standpoint of reliability they seem to have "delivered the goods." Considered from the standpoint of cost, since the cost of power is between 6 and 7 mills per kw-hr., it appears that both mills are rolling steel at a total operating cost of less than 20 cents per ton. This is probably a lower cost than the average steam driven mill. In the plant with the number two equipment an engine driven reversing mill is being operated, rolling a steel schedule which should not require as much power per ton as the one on the electrically operated booming mill, yet the operating cost per ton on the steam mill is at least double that of the electric.

It is interesting to compare the power consumption per ton of steel used by the number one and two equipments.

The averages of the above tables show the number two equipment is using 29.7 kw-hrs. per ton and the number one equipment 19.7 kw-hrs which is 10.0 kw-hrs. more for the number two mill. The six-month run on the number two drive includes several months breaking in and some low tonnages so that a fairer basis of comparison would probably be to take the average of the last three months. This average shows a total tonnage of 22,500 and power consumption of 27.4 kw-hrs. per ton of ingots. This amounts to about 10 per cent higher tonnage and 7.7 kw-hrs. per ton, or almost 40 per cent more power than the number one mill drive required.

A New Method of Burning Crude Oil

Oil Is Gasified in a Specially-Designed Vaporizer Outside the Furnace and Forced Into Combustion Chamber Under Positive Pressure.

By W. K. JANSSEN.

The first to appreciate the value of crude oil or petroleum distillate as a fuel was a Russian inventor who developed and patented a burner for crude oil in the early sixties. His device consisted essentially of a series of griddles, over which the oil trickled, became ignited and burned. A year or two later an American inventor modified this original Russian method by utilizing a series of superimposed pans. The oil overflowed from one pan to another, the film or sheet of oil becoming ignited and burning. This form of oil burning apparatus is still used in many crucible furnaces even to-day. It is known as the Russian pan system. At about the same time a patent was granted in England on an oozing furnace. The bottom of this furnace was covered with a uniform layer of slacked lime beneath which was a series of chambers or vaults, through which the oil entered. On leaving the chambers the oil oozed through the slacked lime which served as a wick.

Another contemporary American patent covered the conveying of oil as a gaseous mixture; the oil was preheated, liberating the lighter oils which were subsequently consumed in the furnace.

First Spray Nozzle.

The first spray nozzle was developed in America a few years later. From that time on there have been innumberable modifications of spray and jet burners. These burners in general may be divided into two classes, namely, high pressure and low pressure types. Aside from the pressure of operation, they also vary in design and construction, depending upon the atomizing agent used. These burners are dependent for their success on the use of air or steam as an atomizing agent. In addition some burners also have incorporated in their construction some form of spiral for mechanical atomization.

The spray burner consists essentially of a fan-shaped spray of steam or compressed air upon which a stream of oil is allowed to trickle, the oil being diffused or atomized and burned. The jet burners, of which there are many types, are so constructed that a stream of oil is swept into and becomes a part of a stream of air or steam, being atomized therein and subsequently burned. The spray and jet types of burners have their limitations, because of their inability to maintain a positive adjustment of the definite amounts of oil and air necessary to assure and produce perfect combustion. This condition is further aggravated by the use of oils of variable specific gravity, which congeal in cold weather. This makes perfect combustion almost impossible without the almost constant attention of the furnace operator.

Because of the inability to properly control the air supply to definite combustion proportions, the quantity of air is usually in excess of theoretical requirements for complete combustion, causing a reduced flame temperature. In the spray and jet types of burners, it is essential that there be an abundance of air in order to assure com-

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Paper read at the American Foundrymens Association, Boston, September 25 to 28. 1917.

plete atomization and avoid smoking. If the burners are adjusted so as to admit a theoretical amount of air, the oil is not thoroughly atomized, resulting in imperfect combustion, accompanied by excessive smoking and attendant reduction in flame and furnace temperature. The great objection to the present methods of oil burning lies in the fact that the vaporization and combustion are practically simultaneous and that both occur within the combustion chamber.

A New Gasifier.

During the past year there has been developed a system of oil burning wherein the oil, instead of being atomized or vaporized, is gasified in a specially designed vaporizer outside of the furnace. The gaseous product is forced into a combustion chamber under positive pressure with a resulting perfect combustion. This method of oil burning consists essentially of producing an oil-gas in a specially constructed vaporizer outside of the furnace proper, through the union of oil and heated air in definite proportions for perfect combustion. The air for combustion is delivered by a compressor at about two pounds pressure and a velocity of 150 ft. per second.

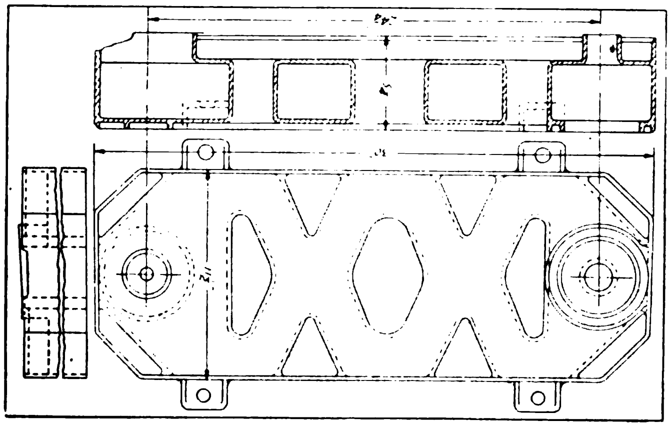

Fig. 1—General arrangement of cast-iron preheater.

The air is forced to the vaporizer through cast iron preheater boxes placed in the path of the out-going gases. With the admixture of oil in the vaporizer, gaseous product is formed which is delivered to the combustion chamber under continuous pressure.

The cast iron preheater, Fig. 1, consists of a closed cast iron box with openings to connecting boxes for the admission of incoming air. A series of vertical flues is provided to permit the passage of the outgoing waste gases through the apparatus, thus providing a source of heat for preheating the air for combustion. The number of preheaters required is dependent on the oil consumption for which the furnace is designed. They are stacked one over the other, and are so placed in the path of the outgoing gases that their walls will transmit the maximum amount of heat. Each heater is provided with an inlet and outlet opening for the admission of air. They are located on the opposite ends of the heater, necessitating a complete passage of air through the apparatus. As the heaters are stacked, the inlet opening of one connects with the outlet opening of another. With this arrangement, the vertical flues are thrown out of line thereby retarding the flow of the outgoing gases, permitting a greater heat absorption through the walls of the preheaters.

Description of Vaporizer.

The vaporizer, Fig. 2, is a hollow cast iron fitting. Its size is dependent on the calculated oil consumption. It has conveniently arranged inlet and outlet openings. Within the vaporizer are a series of baffles which form a winding zig-zag path for the gaseous mixture of air and oil. The long winding passage is essential for complete gasification. The preheated air enters the inlet of the vaporizer and commingles with the oil stream. On striking the first baffle, gasification is begun. The mixture of air and oil gas then winds past the succeeding baffles. It finally is discharged from the vaporizer through a pipe in the furnace wall leading to the combustion chamber.

If perfect combustion is to be attained, the proportions of oil and air must be right and the temperature of the preheated air also must be correct. The installation operates most efficiently when the temperature of the air is about 800 deg. F. Allowing a temperature drop of about 100 deg. for radiation and the conversion of oil to gas, the net temperature of the gaseous mixture is about 700 deg. F. The velocity of the gaseous mixture should be about 150 ft. per second in order to prevent back-firing, or flame propagation in the direction of the scource. This is most essential, as the temperature of ignition, 1,050 deg. F., is only a few hundred degrees higher than the temperature of the gaseous mixture, which in the proximity of the heated combustion chamber almost instantly is brought to ignition temperature.

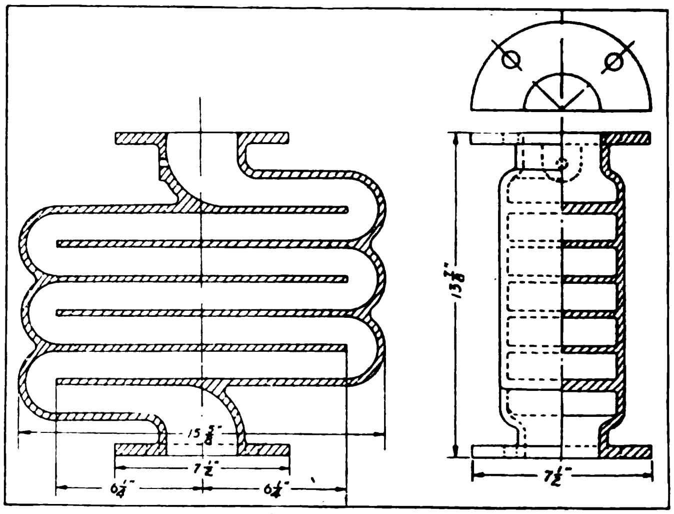

Fig. 2—Details of mixer and vaporizer.

This method of oil burning lends itself very readily to every type of furnace in which the atomizing types of burners have been used. Oil economies of 40 per cent are not uncommon. A 10 per cent economy alone is effected in the preheating of the combustion air.

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PRODUCTION TOPICS

PREVENTION OF TUYERE-BREAST OR BOSH BREAKOUTS

In a recent work entitled "Blast Furnace Breakouts, Explosions and Slips, and Methods of Prevention," F. H. Willcox says in regard to tuyere breast or bosh breakouts: "Safe methods of practice are of little avail in preventing tuyere-breast or bosh breakouts, if by faulty design or construction, weakly built, insufficiently reinforced, or improperly cooled segments of brickwork have been incorporated in this part of the furnace. Modifying methods of practice is of little benefit because of the suddenness with which such accidents occur. Possibly 95 parts of prevention lie in construction and five parts in experiene, resourcefulness, and arrangement of the cast house for accessibility of signals and possibilities of escape.

"The bosh plates should be flushed out regularly to prevent loss of cooling efficiency from sediment depositing in them Hot spots on the bosh jacket should be remedied by putting on additional sprays. The use of longer tuyeres is effective in correcting any tendency to local heating on the side of a bosh jacket. A longer tuyere also diminishes the tendency to cutting about the bosh plates, between the tuyere arches, on the tuyere breast walls, or near the cinder cooler. At best long tuyeres, tuyeres with a smaller nose, or plugged tuyeres are but temporary expedients and if they must be persistently used to prevent fast or abnormal working on the walls and severe erosion, their use is likely to produce off-grade iron and dangerous conditions of scaffolding, hanging, and slipping.

"Regularity of furnace operation brings the discussion into the realm of stock distribution, location of gas offtakes, blast distribution in the hearth, burdening and fluxing, lines of the furnace, use of high heat, regular blast, and the various and many factors contributing to uniformity in practice, freedom from slipping and scaffolding, and long life of the lining. These factors are not without relation to bosh breakouts, but must be passed by with the statement that careful operation is a requisite for prevention.

"The arrangement of the cast house should provide for security in case of bosh breakouts. Means of exit should be provided about the furnace itself, on at least two sides, and in addition there should be an exit from the foot of the cast house. If the cast-house floor is at a considerable height from the yard level, steps or, still better, inclines, should be provided with strong railings. There should be a shield between the snort-valve lever or wheel and the furnace, and the wheel should not be in direct line with a tuyere opening. In addition to the blowing-room signal at the snort-valve wheel an emergency signal should be placed at some other point above the cast house, preferably in some unexposed place outside; for instance, near and behind the No. 1 stove. When this is inconvenient, the emergency signal can be placed in the cast house on the opposite side of the furnace from the one in common use or immediately outside a doorway. A noteworthy safety device is an auxiliary arrangement by which the snort valve on the cold-blast main may be opened from beneath, independently of the cast-house lever or wheel.

"With these arrangements made the last precaution is to insist that members of the force not belonging to the cast-house crew must not make a habit of walking through the cast house in proximity to the furnace. When the furnace is working irregularly, slipping heavily, or being checked after hanging, men should be warned to keep away from the front, from underneath blowpipes, and to use every precaution and be alert when watching the tuyeres."

IRON AND STEEL IN THE UNITED KINGDOM.

The total imports of iron ore into the United Kingdom in 1916 were just under 7,000,000 tons, valued at $57,067,860. The slightly larger imports of 1913 were valued at $34,268,500. About 20 per cent of the imports, 1,500,000 tons, entered the South Wales ports of Cardiff and Newport, and is almost all from Spain. This ore, supplemented by rail and coastwise imports from the midland counties of England and by some local productions, supplied 15 blast furnaces (2 basic and 13 hematite) in South Wales and Monmouthshire, which turned out about 1,000,000 tons of pig iron in 1916. The price of 50 per cent iron ore ex-ship at Cardiff ranged from $9.70 per ton down to $8 until officially controlled. The official price of hematite pig on rail at furnaces was about $30 per ton.

The heavy imports into South Wales of partly manufactured iron and steel from the Continent of Europe ceased entirely, and were replaced only to a negligible extent by shipments from the United States. The figures are probably not complete. Recorded imports into Cardiff from the United States in 1916 of iron brought in bars, angles, and rods were 157 tons, valued at $83,085; of steel blooms, billets, and slabs, 3,598 tons, valued at $218,540; of steel bars, angles, shapes, 4,737 tons, valued at $303,013. No sheet bars nor tin-plate bars appear to have been imported, and absence of these constituted a difficulty for the makers of tin plates and galvanized sheets.

Steel plants were in large measure diverted from commercial production and local and national efforts greatly reduced in volume. For South Wales the recorded exports of partly manufactured steel were only nominal, except to France, which is said to have received large quantities of steel bars. The only recorded exports of steel rails from Cardiff were to India (10,383 tons, $429,576), and to France (8,886 tons, $410,528). Exports of steel rails from the United Kingdom were about one-fifth those of 1915 and far below normal.

Shipments of galvanized iron sheets from South Wales ports in 1916 were 13,000 tons, compared with 47,000 tons in 1913. Exports from the United Kingdom were 117,000 tons in 1916, against 762,000 tons in 1913. Production has almost ceased under commercial conditions. The average price of spelter in 1916 was $333, compared with $110.46 in 1913.

MANGANESE INVESTIGATIONS.

On account of the increasing difficulty in obtaining imported manganese and the vital importance of manganese for the production of the steel needed in making war, the United States Bureau of Mines, Department of the Interior, is making a thorough investigation of the possibilities of relief through a more extensive use of domestic ores. On account of the steel industry being dependent on manganese and on account of the problems of ore concentration being similar to those of iron ore, these investigations have been assigned to the Lake Superior station recently established at Minneapolis. Although the bureau realizes the importance of taking up the iron ore concentration problems at the Lake Superior station as soon as possible, yet such work is obviously to be classified among the "peace-time problems" relating to conservation; whereas the manganese investigation, under present conditions, is strictly a "war problem" dealing with increased production.

Original from UNIVERSITY OF IOWA

NEWS OF THE PLANTS

ENGINEERS' SOCIETY INSPECTION TRIP.

On Saturday afternoon, November 17, the Engineers' Society of Western Pennsylvania, accepted an invitation from the officials of the American Steel & Wire Co. to inspect their new industrial housing development near their Donora, Pa.. plant, also their steel works at Donora.

The housing development consists of 20 double and 60 single houses of monolithic concrete construction. The houses are of eight different designs, all practically fireproof.

The houses are to be occupied by some of their skilled or semi-skilled employees.

The object of particular interest in the steel plant was the duplexing department. There has recently been installed a Bessemer plant, consisting of two 20-ton vessels and one 1,000-ton metal mixer. This plant is operated in connection with the open hearth department, making one of the most modern duplexing installations in the country.

DOMINION IRON & STEEL CO. IMPROVEMENTS.

Improvements now underway at the plant of the Dominion Iron & Steel Co., Ltd., Sydney, Nova Scotia, include the installation of two batteries of 60 ovens each, of the latest type of Koppers'. by-product coke ovens, complete with by-product recovery apparatus, and supplemented by a new Baum coal washing plant.

The original plant of 500 ovens, as erected in 1900, will be abandoned upon completion of the two new units which, with the 1911 installation of 120 Otto-Hoffman ovens (now being rebuilt) will produce sufficient coke to supply their six blast furnaces.

One stack, formerly producing 250 tons per day, is now being remodeled and will have a daily capacity of 400 tons upon completion. about January 1.

Plans are now in hand for a similar enlargement of the other stacks. upon completion of the life of their present linings.

Arrangements are also being made for substantial additions to power equipment and water works.

ARC WELDING DISCUSSED.

O. H. Eschholz, research division. engineering department, of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, presented a paper entitled: "Some Recent Investigations in Arc Welding" at the Philadelphia section of the A. I. S. E. E. meeting held at the Majestic Hotel, Philadelphio, December 1.

The Hess Steel Company, of Baltimore, Md., has awarded a contract to the Crowell-Lundorff-Little Company, Cleveland, O., for the construction of a new electric furnace addition at its works on Loneys Lane. The installation will include electric melting furnaces, power equipment, electric cranes, etc. The plant will be used for the production of electric furnace alloy steel.

The Bethlehem Steel Company, of McAfee, N. J., is making rapid progress in the construction of its new crusher plant at the local limestone quarries.

The Donner Steel Company, of Buffalo, N. Y., has recently had plans prepared for the construction of a new coke plant on Abbey street.

The Anniston Steel Products Company, of Birmingham, Ala., has recently been incorporated under Delaware laws, to operate a local plant for the production of iron, steel and manganese. Walter M. Hood, C. A. Bingham, P. C. Covington, and T. L. Stewart, Birmingham, are the incorporators. The capital is $3,000,000.

The National Steel Products Company, of Bessemer, Ala., recently organized, is planning for the early establishment of a local plant. Bids have been received for the principal equipment for a works with initial capacity of about 15 tons of steel castings per day. A 3-ton open hearth furnace will be installed. J. V. Calvin is secretary.

The Tennessee Coal, Iron & Railroad Co., of Bessemer, Ala., is making rapid progress in the rebuilding of its Little Bell furnace at Robertstown, and it is expected to be ready for operation about the middle of November. It will be devoted exclusively to the production of ferro-manganese. This is the oldest furnace of the company, and has been out of operation for a considerable time.

The Philadelphia Steel Products Company, of Philadelphia, Pa., a Delaware incorporation, has filed authorization papers to operate in New York. H. S. Gould, 37 Wall street, is representative.

The American Steel Products Corporation, of New York, N. Y., has been incorporated with a capitol of $1,000,000 to manufacture iron and steel products. The incorporators are: W. P. Kellett, W. S. Brewster, and W. B. DeLacey, 233 Broadway, New York.

The Ithaca Gun Company, Lake street, Ithaca, N. Y., is making rapid progress in the construction of a new three-story addition to its gun manufacturing plant. The structure will be about 70x100 feet, and is estimated to cost $40,000. George Livermore is president of the company.

The American Ammunition Company, 25 Broad street, New York, N. Y., is making rapid progress in the construction of a new three-story plant at Paulsboro, N. J., to cost about $25,000.

The Carpenter Steel Company, of Reading, Pa., has had plans prepared for the construction of a new one-story addition, about 50x110 feet, to its plant on Exeter street.

The Tioga Steel Company, of Philadelphia, Pa., is making rapid progress in the erection of a new forge shop, machine shop and other buildings at Grays avenue and West Fifty-first street. The structures will cost about $70,000.

PITTSBURGH AND CLEVELAND SECTIONS OF A. I. S. E. E. HOLD JOINT MEETING.

On November 24 the Association of Iron and Steel Electrical Engineers held a joint meeting of the Pittsburgh and Cleveland district sections at Canton, O. The committee in charge of the plans for this meeting consisted of A. H. Swartz, chairman, R. D. Nye, J. G. Donovan, R. Bertz, Jack O'Connor, W. E. Custer, M. E. McGrail, and W. M. Hornlein. The party of engineers visited the United Alloy Steel Corporation mills and the plant of the Central Steel Company at Massillon. A paper on "Central Station Power" was read by W. A. Hornlein and one on "Electric Furnaces" was presented by J. D. Donovan at a session held at the Hotel Courtland on Saturday evening.

INDUSTRIAL SAFETY

SAFEGUARDING ELECTRIC CRANES.

By J. C. Smith.

At this critical period in the history of our country when it is extremely important to conserve the resources of the nation of which the human element is the most valuable, it becomes the patriotic duty of every employer to throw every possible safety protection about industrial workers and to thoroughly safeguard every machine. The following notes on crane construction are the result of the investigation of all available specifications for mechanical safeguards of electric traveling cranes, together with such additions as experience has indicated to be necessary.

Detailed plans of all cranes purchased shall be submitted for approval before a crane is constructed and furnished. Such plants, as well as calculation sheets, shall be submitted to the plant at which the crane is to be installed.

Proper provisions shall be made for all parts subject to impact and rough usage. Journals and shafts shall be of sufficient size to bring pressure and deflections within safe and practical limits. Structural work shall be of open hearth steel and physical and chemical properties shall be governed by the manufacturer's standard specifications for medium steel. All apparatus shall be designed throughout with not less than the following factors of safety under static full load stresses, based on ultimate strength of material used: Gears, drums, blocks, hooks, shafts and other parts except ropes and girders should have a factor of safety of 10; ropes, not less than eight, 6 strands, 19 wires, plow steel; crane girders, not less than five. No cast iron shall be used except for minor parts such as drums, bearing brackets, etc., where strength is of minor importance. No wood or other combustible material should be used.

All bolts shall be through type, bolts to be suitably secured from turning, and equipped with approved lock nuts or lock washers. Bridge motor bolts shall be accessible from above bridge walk. Steps or stairs with hand rails are to be used wherever possible, in preference to ladders.

Footwalks.

Footwalks shall be placed along the entire length, on one or both sides of crane runway, on entire length of bridge on both sides and across the ends, and across the ends of the trolleys at right angles to the bridge walks. Where there is only one walk it should be on the drive side. A safe and adequate means shall be provided to get from walk to walk, and walks shall not telescope. Footwalks shall be of substantial construction, rigidly braced so as to eliminate vibration, and built entirely of steel. Width of main walks shall be not less than 30 inches from outer edge of walk to web of girder. Width of walks on end of bridge shall be not less than 15 inches and on trolley shall be not less than 12 inches. Each walk shall have a standard railing and toe guard at all exposed edges. Railings shall be of riveted structural steel with two horizontal members and not less than three feet six inches high; toe guard shall be at least six inches (net) in height. Floors of walks shall be of checkered steel plate not less than one-fourth inch thick; flooring shall extend from outside toe guard to bridge girder.

Clearances.

Wherever possible all walks shall be so arranged that there will be a clearance for at least six feet six inches between floor of walk and overhead trusses or other structural members; clearance between railing on bridge walk and nearest part of trolley shall be not less than 18 inches. Footwalk shall pass around bridge motor, and may be reduced to a width of twenty (20) inches (clear) at point where it passes motor. Not less than 12 inches actual clearance shall be allowed between highest point of crane and roof chord, and not less than three (3) inches between any other part of crane and building column or other stationary structure. Where there are more than two crane runways in parallel, there shall be a clearance of at least eighteen (18) inches between the extremities of the cranes and a footwalk provided.

Operator's Cage.

Operator's cage shall be securely fastened to bridge girders, and well braced to minimize vibration. It shall be large enough to allow ample room for equipment and operator. The cage shall also be supported by not less than four vertical through stay bolts, having the nuts and plates under the bottom of the cage. Floor shall be of non-combustible material, preferably asbestos. Cage shall be enclosed to a height of three feet six inches above floor with non-combustible material. Stairs should be provided as means of access to bridge walk from cab platform. Steel sash and wire glass should be used in crane cabs. Cab door should swing out. Controllers should be arranged so operator can see hoist hook from any position. There should be a locking device on controller handles and clear indicating marks placed on controller as to how to move handle for certain movements. When there are controllers with external resistance the external resistance units shall be placed outside of the cage. An approved foot or hand operated gong of the rotary type shall be placed in a convenient location and securely fastened. A tray or other suitable guard shall be placed under gong to prevent gong or parts falling. Ladle and other cranes subjected to heat from below shall have a steel plate shield not less than one-eighth (1/8) inch thick and placed not less than six (6) inches below bottom of floor. All cages on hot metal cranes shall have a sheet iron enclosure lined with asbestos, to be used by cranemen in case anything goes wrong with machinery when hoisting hot metal. Provisions shall be made on hot metal cranes so that no man can be confined in any crane cage, or in any other place, where it would be impossible for him to escape to some place of safety, in case of a spill of hot metal.

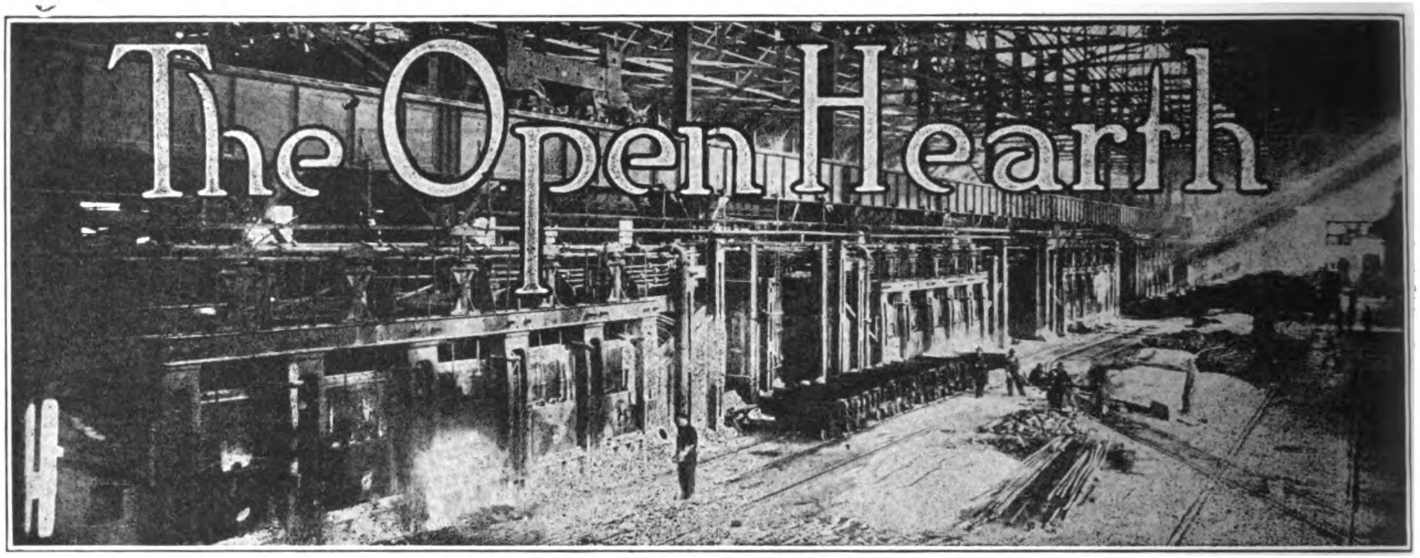
Gears, Couplings, Etc.

All gears including trolley gears, shall be completely enclosed but so guarded as to afford easy access for inspection or repairs. All driving and driven gears shall be tied together in the same steel casting. No overhang gears, except armature pinions, and no split gears, shall be used. Couplings shall be entirely enclosed, the covers being so designed that they are readily detachable, and supported in such manner that they do not revolve with the shaft. Keys shall be secured in approved manner to prevent possibility of gears working loose; they shall be covered or otherwise guarded. Flanged washer with cotter pin projecting through flange and shaft should be provided to prevent trolley power wheels working off.

It is preferable that short shafts be used for trolleys and the trolley sides should be connected with solid cast steel separation to gain separate alignment of trolley.

From paper read before National Safety Council Congress, New York, September.

Original from UNIVERSITY OF IOWA



L. W. Adams, formerly general superintendent of the Saucon plant, Bethlehem Steel Company, is now general superintendent of both plants of the Nova Scotia Steel & Coal Co., Ltd., one located at New Glasgow, N. S., composed of rolling mills, forging plant and bottom nut shop, and the other at North Sydney, consisting of two blast furnaces, five open hearths and coal mines.

√ √

John McConnell, Canton, O., who resigned last spring as general superintendent of the United Alloy Steel Corporation, Canton, is again identified with the above company in doing special work, giving particular attention to all problems pertaining to alloy steels. Mr. McConnell has been one of the leading basic open hearth steel men since the basic open hearth was started at Homestead in 1888. His greatest success has been in the manufacturing of alloy steel of the highest quality.

√ √

Charles C. Capehart, superintendent of the bar mill of the Pittsburgh Crucible Steel Company, Midland plant, has been promoted to chief inspector of the plant, succeeding J. N. Critchlow, who resigned to accept a similar position with the United Alloys Corporation, Canton, O. M. E. Harty, efficiency expert, has been assigned the superintendency of the bar mill. N. T. Gants has been appointed steam and hydraulic engineer. The appointments were effective November 1.

√ √

F. D. Egan, past president of the Association of Iron and Steel Electrical Engineers, who for the past seven years has been steam and electrical engineer of the Midland plant of the Pittsburgh Crucible Steel Company, has accepted the position of works manager of the Pittsburgh Iron & Steel Foundry Co., of Midland, Pa. He assumed charge Nov. 1.

√ √

George E. Lentz, formerly superintendent of construction at Carnegie Steel Company, Farrell, Pa., has accepted a position with Donner Steel Company, Buffalo, effective December 1.

√ √

L. L. Converse, electrical engineer, has become affiliated with the Tacony Ordnance Company, Philadelphia. Pa. He was formerly electrical engineer for the Midvale Steel Company at its Coatesville. Pa., plant.

√ √

E. J. Schwarznau is now chief engineer of the Liberty Steel Company, Warren, O.

Allen Hoffer, formerly superintendent of the blast furnaces of the Worth Brothers Company at Coatesville, Pa., has become affiliated with the ore sales department of the Cleveland-Cliffs Iron Company at Cleveland, O. Mr. Hoffer took up the new work December 1.

√ √

Harry A. Bortz, formerly chief engineer of the Donner Steel Company, at Buffalo, has been employed by L. C. Roberts & Co., of Philadelphia, as resident engineer in charge of construction of the steel works which the Campania Siclerurgica del Mediterranea will build at Sagunto, Spain. L. C. Roberts & Co. are the engineers.

√ √

Carmi C. Thompson, formerly manager of the Great Northern ore properties, with headquarters at St. Paul, Minn., has been made general manager of the ore properties of the Tod-Stambaugh Company, Cleveland, O.

√ √

Rollin C. Steese, a director of the Briar Hill Steel Company, Youngstown, O., has been chosen as one of the five members of the advisory committee of the Ohio Fuel Administration. He was general manager of the Brier Hill Steel Company some years ago.

√ √

Thomas Quinn will act as consulting engineer in the erection of a steel foundry by J. D. Driscoll, of Reading, Pa. The foundry will be built at Hamburg, Berks county, Pa.; electric furnaces will be installed for producing ingots. Mr. Quinn has been connected with the Lebanon Steel Casting Company, Lebanon, Pa.

√ √

C. H. Van Dyke has been elected vice president of the Manown Manufacturing Company, Pittsburgh, Pa., succeeding H. A. Sechrist, who resigned to accept a position with the Mt. Union Refractories Company, Mt. Union, Pa.

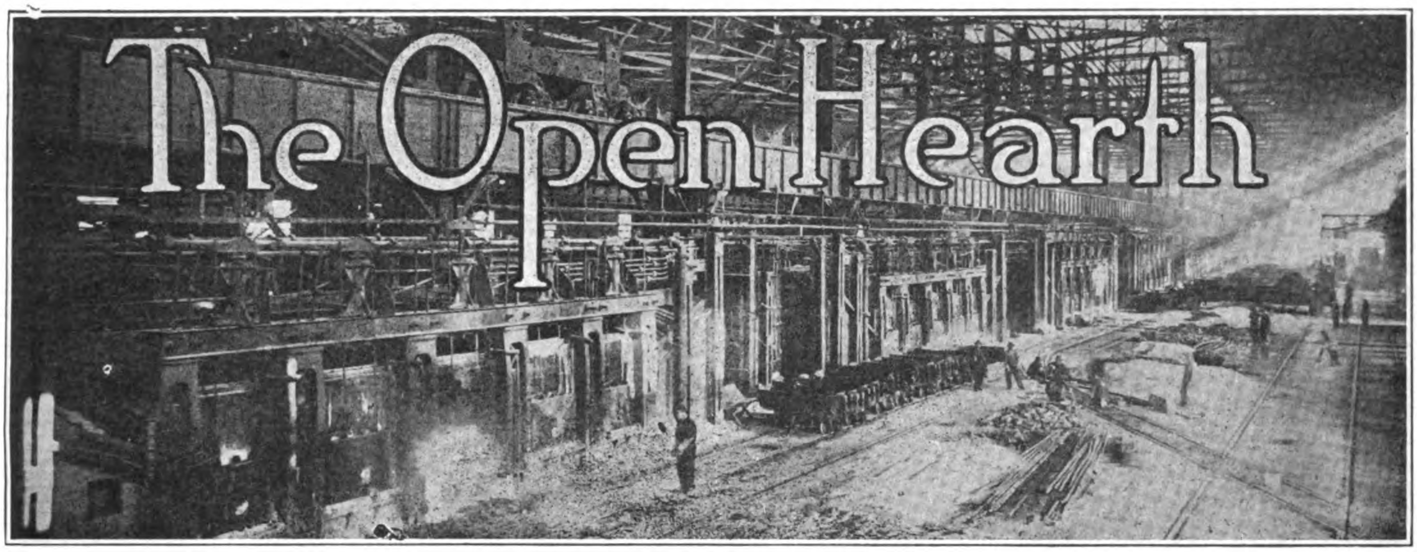
√ √

Walter C. Kennedy has left the Standard Seamless Tube Company, Ambridge, Pa., and accepted a position as electrical engineer with the Pittsburgh Crucible Steel Company, Midland, Pa.

√ √

A. H. Dillon has resigned as assistant sales manager of the Youngstown Sheet & Tube Co. to become head of the Pittsburgh Export Company. Mr. Dillon is devoting his energies to secure the steel needed for the fifty 3,000-ton merchant ships his company is building for the government at Seattle and Tacoma

The Open Hearth



C. M. Replogle has left the Ralston Steel Car Company to become vice president and general manager of the Symington Forge Corporation, Rochester, N. Y., which is at present engaged in executing a government contract for shell forgings.

* * *

R. A. Field, who is now blast furnace superintendent for the La Follette Coal & Iron Co., La Follette, Tenn., was formerly with the Broken Hill Proprietories Company, Ltd., New Castle, New South Wales, Australia.

* * *

Charles K. Logue, formerly connected with the Barney & Smith Car Co., Dayton, O., has accepted a position as superintendent of the foundry of the Albany Car Wheel Company, Albany, N. Y.

* * *

August Jackson has accepted a position as superintendent of the Twin City Forge & Foundry Co., Stillwater, Minn. He was formerly superintendent of the Minneapolis Steel & Machine Co. of the same city.

* * *

Dudley R. Kennedy, formerly head of the industrial relations department of the Youngstown Sheet & Tube Co., Youngstown, O., has been employed by the American Shipbuilding Corporation in a similar capacity.

* * *

Major L. J. Campbell, a vice president of the Youngstown Sheet & Tube Co., Youngstown, O., is now at Camp Sherman, Chillicothe, O. He has been assigned the command of a battalion of artillery.

* * *

Robert J. Mullaly has been chosen by the Carnegie Steel Company to act as assistant superintendent of their McDonald, O., bar mill plant, which is under construction.

* * *

John P. Crum will succeed W. J. Smith as assistant superintendent at the Bessemer Rolling Mills, Bessemer, Pa. W. L. Ballard and P. V. Kolb have been promoted to night superintendent and assistant night superintendent, respectively.

* * *

W. T. Hayes, formerly manager of the American Sheet & Tin Plate Co., Cleveland, O., is now at the Laughlin works of the same company at Martins Ferry, O.

* * *

John A. Green has recently been employed by the Pittsburgh Crucible Steel Company, Midvale, Pa., as superintendent of the steel foundry,

John V. Culliney has accepted a position as superintendent of the plant of the Lake Erie Iron Company, Cleveland, O. He was for many years superintendent of the plants of the American Iron & Steel Co., at Lebanon and Reading, Pa.

* * *

George A. Millar, superintendent of the Bessemer Rolling Mills, Bessemer, Pa., has resigned to supervise new mill construction work at the Fairfield works of the Tennessee Company.

* * *

Walter J. Smith, who has been connected with the Bessemer Rolling Mills, Bessemer, Pa., for a number of years as chief roll designer and assistant superintendent, has been promoted to superintendent, succeeding George A. Millar.

* * *

J. M. Jones, now manager of the sheet and tin plate plant of the Bethlehem Steel Company, Sparrows Point, Md., was formerly vice president and general manager of the Massillon Rolling Mill Company, Massillon, O.

* * *

The various subsidiaries of the Midvale Steel & Ordnance Co. have been merged with the parent company. The concerns now definitely merged are: the Midvale Steel Company, Worth Brothers Company, at Coatesville, and the Wilmington Steel Company, at Wilmington. All of these companies have been controlled by the steel and ordnance company. either by complete ownership or stock control. Henceforth the Midvale Steel & Ordnance Co. will be the operating concern and the above companies will lose their identity, the Midvale Steel Company being known as the "Nicetown Works,' the Worth Brothers Company as the "Coatesville Works," and the Wilmington Steel Company as the "Wilmington Works." The Cambria Steel Company, at Johnstown, the largest unit in the Midvale group, will maintain its name and organization.

The officers elected for the Midvale Steel & Ordnance Co., most of whom held similar positions with the Midvale Steel Company, are: W. E. Corey, chairman of the board; A. C. Dinkey, president; William B. Dickson, vice president; Edwin E. Slick, vice president in charge of operations; John C. Neale, vice president in charge of sales; H. S. Black, assistant to president; D. B. Gehl, treasurer; Robert Brewster, secretary; Marshall Lapham, controller; James M. Milliken, auditor; Joseph Hill and L. K. Krause, assistant treasurers; T. B. Burtis and W. A. Martin, assistant secretaries; S. C. Yeates, purchasing agent, and H. C. Crawford, traffic manager.

Some Pointers on By-Product Coke Oven Operations

PRACTICAL LIMITS OF COKE QUALITY.

As furnace conditions are better understood, the possibility of the use of coke of a wider instead of a more restricted range of quality will become better recognized, with the express limitation that the supply for each furnace must always be absolutely uniform in quality. This requirement of uniformity cannot be too strongly emphasized, and it is almost equally necessary for the proper operation of the coke plant as the blast furnace; but this does not mean that there is one standard grade of coke to which all plants should conform so far as possible. As a matter of fact, the range of cokes that successfully qualify in practical operation is continually being extended, through necessity of one sort or another, with little general realization of the fact.

However, for each kind of coke there is evidently some limiting size for efficient service, i. e., just large enough to offer such a minimum surface of attack for CO_2 that the loss on this account is negligible, and small enough so that complete combustian may be effected in a minimum of time at the tuyeres. Hardness of body is usually—though possibly not necessarily—proportional to the resistance of a given coke to oxidation by CO_2 or oxygen. The harder grades of coke should be used in smaller sizes—and this is a compensation automatically provided to some extent by the operation of the by-product oven. Similarly, cokes of close cell structure are more resistant to oxidation, but this may be offset to a large extent by softness. The coke of more open cell structure will probably require less rigid attention to sizing than the denser coke. The important thing is to determine the practical limits of these elements of size, hardness, and cell structure.

These considerations are of the utmost importance and encouragement to the coke-oven man, because, with a reasonable choice of coal, his control over the quality of his coke is almost unlimited, and, even with a very restricted source of supply, the possibilities of conforming to the desired standard by proper oven construction and regulation are still remarkably great. We propose to conclude this paper by showing two or three examples of what can be accomplished in the way of control of this sort.

One proposition that frequently presents itself is that of eliminating sponge. Sponge is a characteristic honeycombed mass formed in the center of rich volatile matter. It seems to be caused by an excess of pitchy material moving along with the fused zone in the coking process, and finally accumulating in the center of the oven, where it is eventually gasified, with the production of this light porous material. Sometimes this sponge is found in loose, detached masses scattered all over the coke as it lies on the wharf after quenching, or, again, it may be found adhering very closely to the ends of the pieces of coke, and sometimes blending, without any clear line of demarcation, into the body of the coke itself.

Although the amount of this sponge often appears to be very large, it is so bulky that its actual percentage by weight is small. In one case where the amount of sponge seemed to be very large it was actually found that it amounted to 1.65 per cent of the total coke. Small amounts of sponge probably do no harm, most of the material being soon broken up in the operations of handling the coke, but the presence of the material undoubtedly occasions a certain loss of carbon, and so we usually try to get rid of it. The customary remedy—and one that always works—is to mix with the high-volatile coal sufficient low-volatile coal, which has the effect of absorbing the excess of bituminous material and eliminating the conditions of sponge formation. Pocahontas coal is the standard low-volatile coal that is employed by many of our plants. It is to be noted that different coals require considerably different percentages of Pocahontas coal to completely eliminate the sponge.

Frequently it is too expensive a proposition to buy low-volatile coal for the sake of eliminating a little sponge, and sometimes the low-volatile coal may be altogether inaccessible for practical purposes. This does not, however, leave us at the end of our resources. By proper methods of control, sponge may be eliminated from a wide variety of coals that produce it under ordinary conditions. If the oven is correctly designed and proportioned, and the temperature and coking time carefully regulated, very satisfactory results may be obtained without the necessity of making a special coal mixture.

Occasionally one of the most difficult problems to be overcome is that of too great density of cell structure. Here again, we can approach the problem in two ways: one, by mixing in one or more other coals that have a tendency to the production of a more open cell structure, and the other way by suitable preliminary preparation of the coal, careful heat control, and special design of the oven.

To insure the best results a special study must be made of each kind of coal it is proposed to use, and it would be well, in all cases where a new plant is contemplated, to make this study previous to design of plant, because the results may suggest some necessary changes in design that would not otherwise be foreseen.

From a paper presented at a joint meeting of the Franklin Institute and the Philadelphia section of the A. S. M. E., by C. J. Ramsburg and F. W. Speer, Jr.

NEW BY-PRODUCT COKE OVENS.

The Wilputte Coke Oven Corporation, of New York City, has been awarded a contract for the installation of 25 Wilputte regenerative by-product coke ovens, with certain by-product equipment, as an extension to the present coke oven plant of the Algoma Steel Corporation, Ltd., at Sault Ste. Marie, Ontario, Canada. Work will be started immediately, and the construction is expected to be completed by July 1, 1918.

BY-PRODUCT COKE IN THE UNITED KINGDOM.

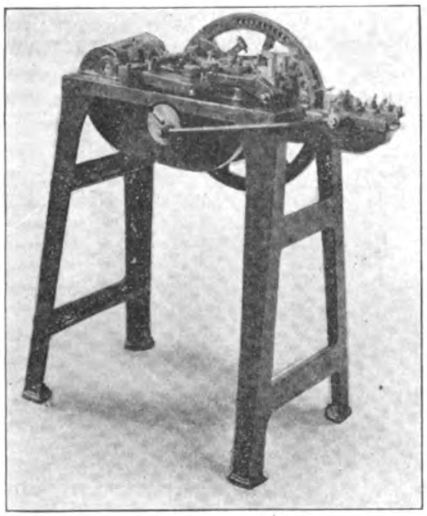
Due to war conditions and the great demand for benzol used in the manufacture of high explosives the by-product coke industry in England has made unprecedented advances. Although the old bee-hive oven had already grown in disfavor before the war, the progress made in the installations of by-product coke plants was until that time rather slow. In 1907, 80 per cent of the coke was made by the bee-hive process. In 1915 the coke produced by colliery companies in the United Kingdom totaled 11,908,940 tons, (this does not include gas or steel works making their own coke), but the relative proportion of by-product ovens to the total had increased from 18 per cent to over 50 per cent. There is no doubt that when the figures are available for 1916 and the present year, the substitution of by-product for bee-hive ovens will be found to be unprecedented.

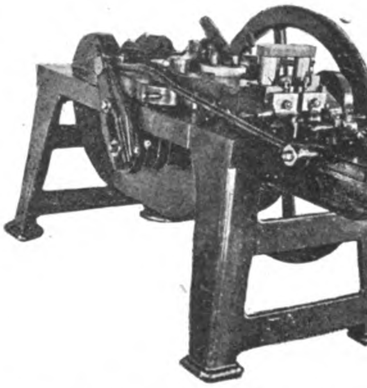
WITH THE EQUIPMENT MANUFACTURERS

A NEW LINE OF WIRE NAIL MACHINES.

A new line of wire nail machines is being built by Sleeper & Hartley, Inc., Worcester, Mass. Among the features which differentiate these machines from others now on the market are the employment of toggle joints actuated from a single crankshaft to provide the working motions, the separation of the pointing and heading operations, and a reduction in size, weight, and floor space occupied.

The machine consists of a frame or bed of massive reinforced construction mounted on double legs. The working members are mounted on top of the frame in such a way, it is pointed out, that they can be lifted off and the machine stripped down in a few minutes. Rotating cams have been entirely eliminated, a single crankshaft controlling the working motions through toggle joints. The operation is said to be smooth and practically noiseless, the power applied being expended in making nails and the wear and tear upon the machine is consequently reduced. The pointing and heading operations have been separated, thus, it is emphasized, reducing the heating effects upon the dies to a great extent and distributing the working stresses more widely. This separation is effected by the use of an intermittently operated carrier wheel interposed between the pointing and heading positions. A series of holding jaws is provided for the wheel which takes a pointed blank from the dies and carries it through a semicircle into the heading position, where the heading dies complete the work. The jaws still hold the nail until another quarter revolution of the carrier wheel has been made when the nail is automatically released and dropped. This wheel normally holds from three to four pointed blanks and is operated through a Geneva motion from the main crankshaft. The pointing and heading dies are readily accessible, it being possible to lift any one of them off in a few seconds for examination. Adjustable compensating wedges are provided to take up wear in all the important bearings and the adjustments for the anvil and dies are made in the same way.



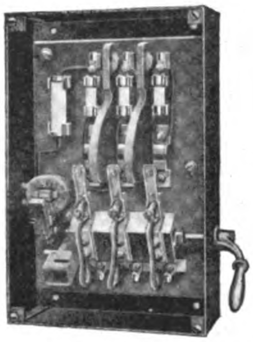


In operation the wire is taken from the coil and fed through a set of straightening rolls mounted on the feed slide. An adjustable connection from the crankshaft operates the slide, which in the larger machines is provided with a quick return motion. In a single revolution of the machine the wire is fed forward to form the nail blank, which is cut off and the incoming end pointed at the same time. In the meantime a previously cut-off blank is being headed on the opposite side of the carrier wheel, which is then moved through a partial revolution, thus releasing a nail that has been previously headed.

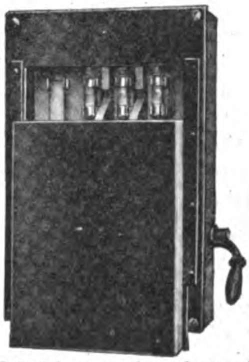
Five sizes of machines are built for making nails from ¾ to 10 inches long, from No. 17 wire, to material that is ⅜-inch in diameter. The next to the smallest size of machine has an output of 400 nails 2½ inches long, from No. 11 wire, in one minute. This machine occupies a floor space of 19 x 42 inches, and weighs but 750 pounds. The next size, which is the middle one of the series, occupies a floor space of 36 x 63 inches., and weighs 2,000 pounds. This has an output of 350 nails 4 inches long, from No. 6 wire, per minute.

STARTING SWITCH.

The new C-H enclosed starting switch provides the motor with protection against overload and against unexpected re-starting after there has been an interruption in the circuit or failure of voltage. It also insures safety to the operator under all conditions, because he cannot touch a live part while operating the switch, nor when inspecting or renewing fuses. The sliding panel, which encloses the contacts and fuses, interlocks with the mechanism so that the switch cannot be closed and the fuses are always dead when the sliding panel is in the lowered position. With the panel in its closed position the starting handle may be operated. The fuses are not in circuit when starting but are automatically included in the motor circuit when the starting handle reaches the running position. The fuses can therefore be of sufficiently low capacity to give proper protection to the motor windings. Failure of voltage causes the switch to open. Unexpected re-starting with the resultant possibility of injury to operator or machine driven is prevented because to again start the motor it is necessary to operate the starting lever.



Enclosed panel removed showing interior of ac switch.



C-H 9116 ac enclosed starting switch with enclosed panel lowered. This interlocks the switch in the open position.

The interior parts consist of three moving contact fingers, which, when the starting lever is moved to the extreme upward position, make contact with three stationary contacts, connecting the motor directly to the line. This is the "start-

Original from UNIVERSITY OF IOWA

WITH THE EQUIPMENT MANUFACTURERS .

ing" position. After the motor is up to speed, the hand is removed from the handle and the contact fingers slide into engagement with the running contacts, the change being made without opening the motor circuit. The capacities of this standard switch is 3 hp, 110 volts; 5 hp, 220 volts. It is designed and made by The Cutler-Hammer Manufacturing Company, of Milwaukee.

USE OF MAGNETIC PULLEYS.

The use of magnetic separator pulleys has increasel to a great extent during the past few years. For example, they are used with success in removing pickheads, coupling pins, etc., from coal passing to a crusher which would be damaged by the entrance of such material. They are used for similar purposes at phosphate rock mines and quarries. In production of sulphite fibre paper stock, they are used to remove tramp iron and steel from the wood before these are delivered to the sulphate tanks. In the blast furnace they are used to remove magnetic content from the blast furnace slag; in foundries, to remove metal from the sand to prevent damage to facing mixing machines; in the steel plant to remove iron from the scale coming from the rolls and squeezers. They also find employment in city refuse disposal plants, for removing tin cans, horseshoes, nails, etc., from the worthless material. The high cost of metals has made the saving of metal turnings and separation of iron and steel from brass well worth while.

The use of powdered or pulverized fuel has been extended and this has led to the need of magnetic separators in cement plants, steel plants, power houses and many other kinds of plants. For open hearth furnaces, a brief mention here of the process of furnishing the pulverized coal and the use of the magnetic separator.

First the tramp iron is removed from the coal by means of magnetic separators. Coal as delivered to the milling plant always contains an astonishing amount of tramp iron in the form of bolts, nuts, rivets, nails, bar iron, railroad spikes, muleshoes, etc. Any of these materials entering the crusher or pulverizer might result in damage to the machine, with consequent delays in operation.

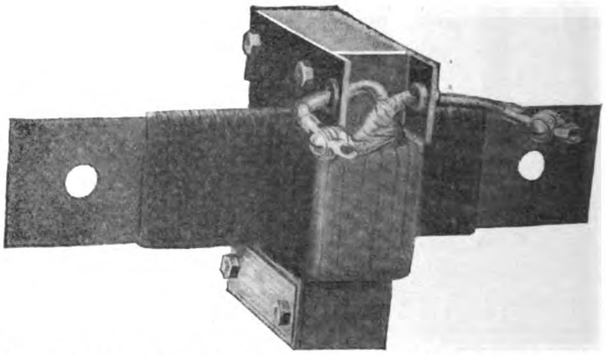
The foreign material can be entirely eliminated by the use of a magnetic separator, located at some point ahead of the crusher. When the material passes over the pulley which contains the magnet, the magnetic material, consisting of tramp iron, is attached and held firmly against the belt and remains in contact with the belt until it leaves the magnetized zone, which is at some point beyond the under side of the magnetic pulley. The tramp iron drops from the belt after it leaves the pulley and is delivered to suitable boxes by means of a chute, the coal continuing on its course.

The shortage of natural gas caused the Missouri, Kansas & Texas Railroad to decide upon pulverized fuel for the water tube boilers in the power house of the shops at Parsons, Kan. The equipment for pulverizing and drying fuel is contained in a separate building, which is located near one end of the boiler house, and the coal is dumped from the cars directly into a concrete track hopper adjoining this building. The plant is designed to handle either mine run or slack coal, and immediately below the track hopper is placed a set of rolls, which reduce lumps up to 12 x 18 inches to 5-inch cubes or less in one operation. As the coal passes through this crusher, it drops onto a belt conveyor, which discharges diretly into a set of corrugated rolls. The upper end of the belt conveyor passes over a 24 x 22 inch Cutler-Hammer magnetic separator pulley, the function of which is to remove any pieces of iron or steel which may be in the coal and retain them on the belt until the latter passes off the underside of the pulley, the metal then dropping to the floor behind the crusher. This crusher reduces the coal to pass through a ¾-inch mesh or less, and delivers it into a dust-tight elevator, from which it is distributed into a storage bin over the coal dryer.

CHEAPER PROTECTION FOR ELECTRICAL DEVICES.

Suppose something—a short circuit for instance—should take place on the power line in your locality and the machines in the station which send you current should happen to be unprotected. Serious damage would almost certainly result—lights might be out for hours rather than minutes—fans, motors, heating devices and vacuum cleaners would cease their operation.

But, of course, this rarely happens, for protection is usually adequate. Circuits are safeguarded automatically by electrically operated devices which, opening under unusual stress, cut off the circuit at a sign of danger.



Tripping transformer for protecting electrical circuits.

As a rule, these automatic devices receive the power which causes them to open the circuit from "current transformers" which change the current from a large to a small quantity and keep the dangerous "voltage" or high pressure away from the automatic devices. The transformers also assist measuring instruments in their duties as indicators and recorders of the current or power on the line. When thus used the "transformers" must possess high accuracy and hence are quite expensive.

Today if measuring and recording are unnecessary, as is true in many cases, a small "tripping transformer" (see illustration), designed recently by the General Electric Company of Schenectady, N. Y., may be used in connection with the automatic device.

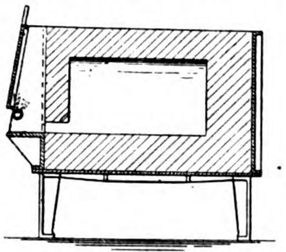
This eliminates the higher price of the more accurate transformer and since the new device is accurate enough for tripping purposes, it offers a similar advantage, that is, it results in a simpler, cheaper, and safer arrangement.

Although small and inexpensive, the new "invention" offers a convenient and very satisfactory method of safeguarding valuable apparatus.

RECENT PATENTS

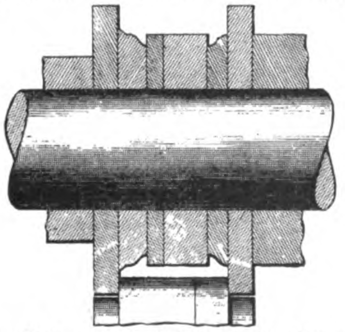
Furnace Shield.

1,245,030. Walter S. Rockwell, New York, N. Y., assignor to W. S. Rockwell Company, New York, N. Y. The patent combines a furnace front, applied to the doorway of a furnace which emits hot gases, with a hood open at the top and acting as a draft flue The furnace front has a sill on the level with the floor of the furnace, over which sill the hood is suspended. A shield which is supported adjustably upon the front, is constructed so that it may be moved to and from the sill to prevent the forward discharge of gas. A blast pipe, situated at the mouth of the hood, operates as an injector to draw the hot gasses from the open doorway into the hood.



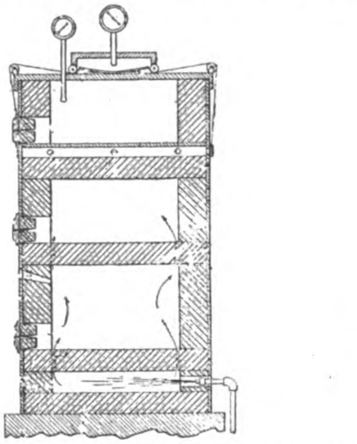
Roll Construction for Rolling Mills.

1,244,464. William J. Bradley, Troy, N. Y. A roll for rolling shapes with spaced inside shoulders, the same including a pair of opposite marginal die-rings provided with shoulder shaping die surfaces, and an intermediate ring interposed between the marginal rings and provided with a flat peripheral die surface and with flat shoulder shaping die edges, the latter overhanging the die surfaces of the marginal rings, the said intermediate ring being interchangeable with similar rings of different widths.



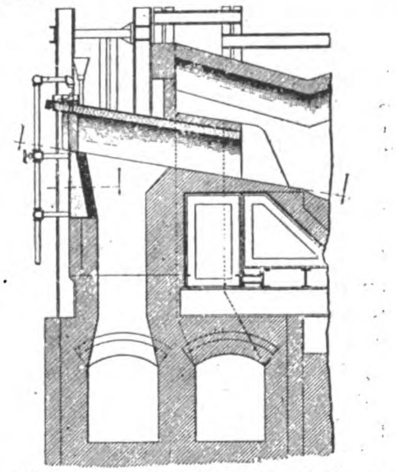
Steel Heating Furnace.

1,244,578. William R. Bennett, Elmwood, Conn. The invention consists of a furnace for treating steel pieces, comprising three superposed heating chambers, a combustion compartment positioned immediately below the lowest chamber, passages disposed uniformly in or near the periphery of the floors of the lowermost chambers, to provide communication for the products of combustion through the two lowest chambers, said uppermost chamber being out of communication with the products of combustion being heated by the heat of the chamber below, the furnace having an air space below the floor of the uppermost chamber and said chamber having means for the admission of air at given intervals to reduce or hold at a given degree the temperature of the uppermost chamber.



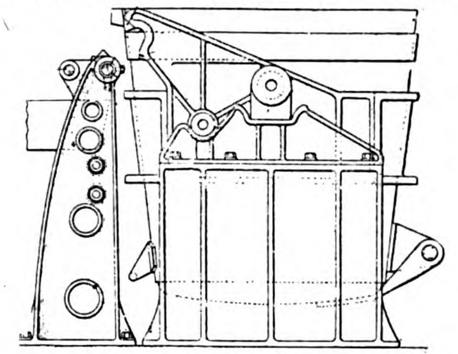
Open Hearth Furnace.

1,245,555. Thomas S. Blair, Jr., Chicago, Ill., assignor to Blair Engineering Company, New York, N. Y. The invention consists of walls so arranged as to form a gas port and a downtake communicating with it, the upper part of the end wall of the downtake being faced with chrome ore, immediately below the entrance of the gas port. A series of water cooled shelves maintain the facing in place.



Pouring Apparatus for Hot Metal.

1,246,783. Edgar J. Reilly, Youngstown, O., assignor to The William B. Pollock Company, Youngstown, O. This invention consists of a fixed stand so constructed as to receive the bearing surfaces of the lugs of the ladle on a rotatable cradle by means of which the cradle may be tipped. The stand of the invention is equipped with a ladle guard.

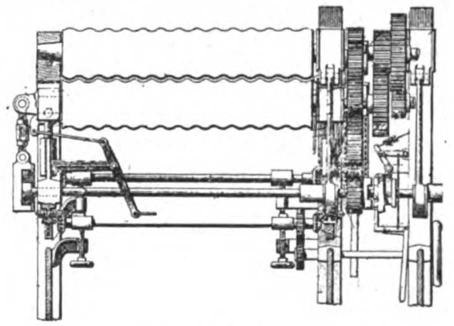


Method of Operating Furnace and Oven Apparatus with Recovery of Heat.

1,246,114. Heinrich Koppers, Essen-on-the Ruhr, Germany, assignor, by mesne assignments, to H. Koppers Company. In operating a regenerative furnace heated by producer gas, the method of effecting a draft reversal which consists in interrupting the air supply and steam supply to the gas producer to stop the production of gas therein, putting the furnace off the gas producer, changing the position of the air valves and waste gas valves of the furnace, and reconnecting the furnace and the air and steam supply to the gas producer.

Pipe Rolling Machine.

1,245,827. Cowles Mead Vaiden, Vaiden, Miss. This patent comprises a pipe rolling machine, so constructed that the lower and rear rolls may be vertically adjusted; the rear roll being adjusted by manual means and the lower roll by the rotation of the rolls. A bearing for one end of the lower roll, hinged to the frame of the machine, is operated by the rotating apparatus so as to swing outward and afterward raise the upper roll. A device is provided so that the raising of the upper roll lifts the rolled pipe from the lower roll and the swinging of the bearing provides means for stripping the pipe.



Trade Publications

Hardness Testing Machine—A recent 12-page bulletin by Scientific Materials Company, Pittsburgh, Pa., shows construction and application of their improved Americal model, Brinell hardness testing machine.

Sherardizing Furnaces—General Electric Company has issued Bulletin No. 48,926, describing electrically heated sherardizing devices which they have on the market.

Industrial Safety—"Safety First," published by the Youngstown Sheet & Tube Co., of Youngstown, O., is a general review of the safety work at their plant, written by J. M. Waltz, safety director.

Steel Mill Safety—"Rules and Instructions" is a booklet which the Youngstown Sheet & Tube Co. presented to all their employes and contains the pick of the most practical and necessary steel plant safety rules in existence, together with elementary first aid instructions.

Containers—"Blaw Holding Drums and Their Limitations" is the title of a new folder received from Blaw-Knox Company, Pittsburgh, Pa., which is just a little bit different from the general run of advertising literature.

Draft Recorders—A complete description of the hydro pressure and draft recorders is contained in catalogue "D," issued by Bacharach Industrial Instrument Co., 422 First avenue, Pittsburgh, Pa. Besides explaining the design and construction of the recorders, this pamphlet shows the different types of the hydro draft and pressure recorders, together with the many uses and applications in the different fields of industry.

Efficiency Devices — The Esterline Company, Indianapolis, Ind., publishes a monthly bulletin, "The Esterline Graphic," which will be mailed to those interested in industrial efficiency.

Pumps and Compressors — Ingersoll-Rand Company, Easton, Pa., have just issued the following leaflets describing their products. Copies may be had upon request. Form 859—4 page leaflet on "Pocket Oil Flask." Form 858—"Steam Condensing Plant." Form 3118—32 page catalogue on "Compressors and Vacuum Pumps for Extraction of Gasoline from Natural Gas." Form 4302—20 page catalogue on "Sergeant Rock Drills."

Tumblers and Dust Arresters—Catalogue 132, issued by the Whiting Foundry Equipment Company, Harvey, Ill., describes their line of tumbling and dust arresting equipment.

Department of the Interior, Bureau of Mines, has issued the following new publications: Bulletins — Bulletin 131, "Approved Electric Lamps for Miners," by H. H. Clark and L. C. Ilsley. 1917. 59 pp., 17 pls., 7 figs. Bulletin 136, "Deterioration in the Heating Value of Coal During Storage," by H. C. Porter and F. K. Ovitz. 1917. 38 pp., 7 pls. Bulletin 141, "Yearbook of the Bureau of Mines, 1916," by Van H. Manning. 1917. 173 pp., 17 pls., 8 figs.

Technical Papers—Technical Paper 167, "Men Who Received Bureau of Mines Certificates of Mine Rescue Training, July 1, 1914, to June 30, 1916," compiled by D. J. Parker. 1917. 66 pp. Technical Paper 173, "Coke Oven Accidents in the United States During the Calendar Year 1916," compiled by A. H. Fay. 1917. 19 pp. Technical Paper 175, "Production of Explosives in the United States During the Calendar Year 1916," compiled by A. H. Fay. 1917. 24 pp.

Handbook—"Advanced First Aid Instructions for Miners; a Report of Standardization," by C. H. Halberstadt, A. F. Knoeffel, W. A. Lynnott, W. S. Rountree, and W. J. Shields. 1917. 154 pp., 65 figs.

Note—Only a limited supply of these publications is available for free distribution and applicants are asked to co-operate in insuring an equitable distribution by selecting publications that are of especial interest. Requests for all papers can not be granted. Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

Society Meetings

National Safety Council, annual congress for 1918 will be held at St. Louis, Mo., the third week in October, 1918. Headquarters will be at the new Stattler Hotel. W. H. Cameron, general manager, Continental & Commercial Bank building, Chicago, Ill.

Engineers' Society of Western Pennsylvania, December 4, 1917, meeting, "Manufacture and Use of Die Castings," by Charles Pack. December 18, 1917, meeting, "Gears," by J. H. McAlpine. Both meetings in the Union Arcade building auditorium.

At the Philadelphia section of the A. I. S. E. E., to be held in Philadelphia, January 5, Messrs. John C. Reed and Merwyn J. Hocker, electrical engineers of the Bethlehem Steel Company, Steelton, Pa., will deliver a paper entitled "Electrically Operated Bridges."

Pittsburgh section A. I. S. E. E., Youngstown, O., December 15.

American Society of Mechanical Engineers, New York City, December 26-29.

American Mining Congress, State Chapter, Phoenix, Ariz., December 26-29.

American Society of Mechanical Engineers. Monthly meeting, first Tuesday. Calvin W. Rice, secretary, 29 West Thirty-ninth street, New York City.

Providence Engineering Society. Monthly meeting, fourth Wednesday of each month. A. E. Thornley, corresponding secretary, P. O. Box 796, Providence, R. I.

Trade Notes

E. S. Lincoln, Inc., announce a change in location from 25 Silver street, Waterville to 534 Congress street, Portland, Me. This change will enable them to render more prompt and better service.

H. A. Brewer, formerly advertising manager of the Electric Controller & Manufacturing Co., has joined the National Army. He is succeeded by H. H. Volck.

W. C. Renkin, formerly chief engineer for the A. M. Byers Company, of Pittsburgh, Pa., is now manager of the engineering department of the Quigley Furnace Specialties Company, 26 Cortlandt street, New York City. His department will specialize in powdered coal installations.

R. L. Browne has recently become associated with the Goldschmidt Thermit Company, of New York City, as commercial engineer. He has been identified with electrical and mechanical engineering professions for 15 years and has spent several months in the foundry of the Thermit company, acquiring a knowledge of thermit welding.

H. Norman Brooke and F. H. Brooke, of Sheffield, England, have acquired the exclusive manufacturing and selling rights on Maccallum Metal-Kase Brick in Great Britian. The Messrs. Brooke manufacture large quantities of silica and magnesite brick at their Cleveland, England, works. They are associated with Benjamin F. Talbot, of the Cargo Fleet Iron Works and inventor of the Talbot steel making process.

W. F. Trenary, Jr. succeeds W. R. Jemison as representative of the Harrison Safety Boiler Works, of Philadelphia, Pa., manufacturers of steam plant appliances. His offices are at 419 Brown-Marx building, Birmingham, Ala.

R. J. Morgan, who has resigned his position with the Midvale Steel & Ordnance Co., has been appointed supervisor of sales of the American Steel Export Company, New York. Mr. Morgan, prior to his connections with the Midvale Steel & Ordance Co., spent 13 years with the Carnegie Steel Company.

The Electric Furnace Construction Company, of Philadelphia, announce the sale of a "Greaves-Etchells" electric furnace to the Ford Motor Works, of Detroit, Mich. The Halcomb Steel Company of Syracuse, N. Y., have purchased two 3-ton furnaces. Both of these concerns will use their new furnaces in connection with government aeroplane work.

Charles L. Hall, prominent structural and mechanical engineer, has left the construction department of the Armour Company, Chicago, Ill., to join the staff of Booth-Hall Company, 565 West Washington street, Chicago, Ill., manufacturers of electric steel furnaces. He will act as production manager.

CUMULATIVE INDEX

The Blast Furnace and Steel Plant

March 1913 to December 1917

The following is a cumulative index of all feature articles having appeared in THE BLAST FURNACE AND STEEL PLANT since its inception. An attempt has been made to index the articles under subject headings rather than in alphabetical order; thus placing the source of required information in the most practical form. In addition to articles tabulated in this index the following departments appear regularly each month:

Production Topics, News of the Plants, Industrial Safety, Open Hearth, Some Points on By-Product Coke Oven Operations, With the Equipment Manufacturers, Recent Patents, Trade Notes, Trade Publications and Society Meetings.

BESSEMER PROCESS

Bessemer and Open Hearth Temperature Gaging—George K. Burgess, Mar., 1917, p. 117.

Application of known pyrometric devices to measurement of molten iron and steel temperatures. Corrections to be observed for accuracy.

Roll Scale As a Factor in Bessemerizing—A. Patton and F. N. Speller, Apr., 1917, p. 161.

Use of otherwise waste product in facilitating control of pig iron refinement in the converter. Mill records to show effect of varying additions to blow. Effect of moist scale.

Temperature Measurements in Bessemer and Open Hearth Practice. May, 1917, p. 225.

Investigation of Bessemer Converter Action—W. Trinks, Jan., 1916, p. 25.

Why is the blast pressure in a Bessemer converter several times that necessary to overcome the ferrostatic pressure? This and other problems of converter operations are being attacked in this series of tests.

Discussion: S. P. Bush and R. P. Flinterman, June, 1917, p. 251.

The manufacture of steel castings.

Need for High Air Pressures in Tuyeres—W. Trinks, Feb., 1917, p. 53.

Report on experiment carried out with experimental apparatus to determine effect of blast pressures in Bessemer tuyeres. Atomizing of charge conditions sought.

BLAST FURNACE

Blowing Engines.

Short Drives for Compressors. May, 1916, p. 244.

Gas Engines at Blast Furnaces and Steel Plant. July, 1913, p. 14.

Testing Blowing Engines for Leakage. June, 1913, p. 54.

Reliability of Blowing-Engine Indicator Cards—W. Trinks, Mar., 1914, p. 18.

Measuring Air Delivered by a Turbo Blower—Thomas G. Estep, Jr., Dec., 1917, p. 558.

Combination of standard orifice and pitot tube used for accurately measuring air delivered from turbo blower to blast furnace. Static measurement eliminated.

Turbo Blower and Compressor Regulators—W. Trinks, Sept., 1916, p 426.

Adapting the turbine driven unit to the various services around the blast furnaces and steel plant through proper application of regulating devices.

Air Delivery Factors of Blowing Engines—W. Trinks, Dec., 1916, p. 551.

Showing wherein various characteristics of the engine may contribute toward the air supply. Typical examples from practical experience found by investigators.

Operating Characteristics of Turbo Units. July, 1916, p. 317.

Discussing the similations and applications of turbo units for high duty blowing and pumping service. Characteristics to be considered in their installation.

Regulating Turbo Blowers or Compressors—Carl Grosswendt, Feb., 1916, p. 76.

Means of obtaining specified operating conditions under varying handicaps. Using turbo blowers for meeting irregular blast demand at efficiency power draft.

Causes of Pre-Ignition in Operation of Blast Furnace Gas Engine. March, 1915, p. 273.

Experimental determination of possible governing factors in coke conditions, amount of water vapor present and other contributory causes of irregularity in firing cycle.

Performance Record of Gas Blowing Unit. July, 1915, p. 694.

Operating characteristics of large blast furnace gas engine installed at Pennsylvania Steel Company's plant at Steelton. New feature proving successful.

Modern Gas-Power Blowing Stations. March, 1915, p. 295.

Turbo Blowers for Blast Furnace Use. May, 1914, p. 34.

Improving Blast Furnace Blowing Engine. Oct., 1917, p. 456.

Blowing capacity of existing plants increased by installing automatic plate valves. Methods of rebuilding blowing engines. Reciprocating engines vs. turbo blowers for blast furnaces.

Turbo Blowers in Steel Mills. Oct., 1917, p. 471.

Removing Old Engine Bases. Feb., 1917, p. 78.

Burden.

Powdered Coal as a Blast Furnace Fuel. July, 1916, p. 315.

Boosting the furnace by blowing pulverized coal into the tuyeres. High heats possible with very little change in existing stack equipment. Coke reduction secured.

Uses of Extra Coke on the Blast Furnace—Wallace O. Imhoff, Jan., 1916, p. 13.

Enumeration and classification of the need for more than the theoretical smelting amount of coke on the burden of the working stack. Operating for coke savings.

Stock Lines and Top Considerations. May, 1915, p. 514.

Recording burden level in working furnace under all conditions of operation. Value of mechanical filling bar. Larger stacks demonstrated in actual practice.

Combustion Notes on Blast Furnace Coke—Herman A. Brassert, Sept., 1915, p. 834.

Wherein particular references is made to the combustibility of furnace fuel. Influtions at stack. Physical and chemical factors of weight.

Puddle Cinder as a Blast Furnace Burden—Wallace G. Imhoff, June. 1916, p. 284.

The cinder from puddling furnace is often offered the merchant furnace buyer as ore. Considering this material from the point of view of the furnace operator.

Blowing-in Burden of a Blast Furnace—Robert Rollin, Sept., 1913. p. 22.

Calculations Covering Carbon in Furnace—J. W. Richards, Feb., 1917, p. 67.

Discussing paper by H. P. Rowland, which appeared in these columns in May, 1916, issue. With diagramatic of carbon per ton of iron as distributed.

Fixing Furnace Burden from Analysis—R. Rollins, Feb., 1914, p. 44.
See also Blast Furnace Construction.

Chemical Reactions.

Reactions and the Heat Balance of the Blast Furnace. Oct., 1913, p. 18.

Desulphurization in the Blast Furnace. Aug., 1916, p. 394.

Method and procedure on desulphurization in the blast furnace.

Recent Blast Furnace Advancement. Aug., 1915, p. 757.
See also Blast Furnace Operation.

Recent Blast Furnace Advancements—A. E. Maccoum, Oct., 1915, p. 915.

Carburizing Iron in Blast Furnace Gases—T. H. Bryom, Nov., 1915. p. 1,001.

Interesting cases of change in chemical structure of materials suspended within sphere of influence of gases from blast furnace. Cause of mysterious failures located by this research.

The Chemical Reactions of Iron Smelting—Walther Mathesuis, June, 1917, p. 258.

The application of actual practice to the chemical theories involved in direct and indirect reductions. Solving the problem of premature combustion. Praise for the coke producer.

Chemical Reactions of Iron Smelting—Henry P. Howland, July, 1917, p. 325.

Sulphur as a Component of Furnace Slag—Wallace G. Imhoff, Aug., 1917, p. 358.

Free and sublimated sulphur. Causes of high sulphur iron. Relations to various furnace conditions, such as hearth temperatures, fusion zone and furnace driving. Effect on slags.
See also Blast Furnace Operation.

Construction.

Electric Skip Hoists for Blast Furnace Use—H. D. James, Feb., 1917, p. 71.

Design characteristics of ac. and dc. motors when used for skip control. Obtaining accurate slow-down and stop without adding excessive apparatus to installation.

Blast Furnace Construction. June, 1913, p. 28.

Model Blast Furnace. Sept., 1916, p. 438.

Description and illustrations of model of furnace designed and fabricated by the Bethlehem Steel Company, Lehigh plant.

Distributing Blast Furnace Raw Materials—George W. Vreeland, Aug., 1916, p. 382.

Concluding a discussion of the application and operating characteristics of the types of tops and distributing devices in use at modern installations.

Distributing Blast Furnace Raw Materials—George W. Vreeland, June, 1916, p. 268.

Discussing the applications and operating characteristics of the types of and distributing devices in use at modern installations. Probable trend of development.

Will a Forty-Ton Stack Pay Overhead, Sept., 1916, p. 422.

The question of a small stack confronts a community. Expert opinion discounts the feasability of such an installation on a paying basis under normal conditions.

German Adoption of Neeland Skip Bucket. Feb., 1916, p. 90.

Presenting the curious fact of an American bucket finding wider use abroad than at home. The Neeland charging bucket as used in Germany.

Modern Blast Furnace Erected in 85 Days. July, 1916, p. 320.

Cambria Steel Company makes remarkable record in building 500-ton furnace. Fast time due to new efficiency methods, gang organization, co-operation of departments and men used.

Influence of Distributor on Stack Burden—J. C. Barrett, July, 1916, p. 323.

Showing how the McDonald distributor serves the needs of the furnace by remedying imperfect skip filling and discharging. Securing uniformity with little effort.

Single Stack Stock Handling Problems—Charles C. Lynde, Aug., 1915, p. 752.

Storage and easy access to materials. Questions bearing on scope of ore furnace plants. Seasonal as well as market conditions to be met by merchant furnace operator.

Electric Motor Drive for Bell Hoists. Feb., 1917, p. 74.

Skip Hoists for Automatic Handling—H. V. Schiefer, Sept., 1917, p. 402.

Classification of various types of skip hoists. Comparison of automatic and semi-automatic control. Handling of coal, ore, blast furnace burden, ashes and clay.

Cinder Notch Stopper. Sept., 1917, p. 414.

By-Products.

Utilization of Flue Dust—The Greenwalt Sintering Process—L. M. Smith, July, 1913, p. 29.

The Blast Furnace as a Potash Producer. June, 1916, p. 296.

Potash from slag. Blast furnace by-products.

Potash as a Furnace By-Product—R. J. Wysor, Feb., 1917, p. 72.

Outlining the possibilities of a new field for blast furnace savings, in the saving of potash and derivatives. Occurrence and nature of deposits within furnace.

Potash as One Blast Furnace By-Product—R. J. Wysor, Mar., 1917, p. 110.

Continuing the outline of the possibilities for recovering potash and its compounds from the flue dust deposited by the blast furnace and its auxiliaries.

Potash as One Blast Furnace By-Product—R. J. Wysor, Apr., 1917, p. 167.

Concluding the discussion of the possibilities involved in the blast furnace as a producer of potash and compounds in commercial quantities. Results from furnace comparisons.

By-Products in Iron and Steel Manufacture. July, 1914, p. 40.

Blast Furnace Gas.

Stack Gas for Boilers and Hot-Blast Stoves (Part 1)—A. N. Diehl, Nov., 1915, p. 989.

Discussing minutely the adaptation of various burner and stove conditions which may or may not make for economical combustion of blast furnace gas.

Stack Gas for Boilers and Hot-Blast Stoves (2)—Ambrose N. Diehl, Dec., 1915, p. 1,045.

Second part of series discussing burner types and efficiencies found in actual working conditions in stove and boiler installations. Test figures from representative plants.

Modern Methods of Using Blast Furnace Gas Under Stoves and Boilers (Part 3)—A. N. Diehl, Jan., 1916, p. 27.

Continuation of discussion of types of burners for stove use, with conclusions covering principal types of burners for boiler work, with series performance figures from representative corporation plants.

Modern Methods of Using Blast Furnace Gas Under Stoves and Boilers (Part 4)—A. N. Diehl, Feb., 1916, p. 79.

Representative boiler test figures used as basis for compariso of burner characteristics. Indirect and direct test results compared as to findings.

Modern Methods of Using Blast Furnace Gas Under Stoves and Boilers (Part 5)—A. N. Diehl, Mar., 1916, p. 129.

Obtaining ideal conditions for the performance of boilers during test. Eliminations of air leaks and scale as other evaporation retardants before operating.

Modern Methods of Using Blast Furnace Gas Under Stoves and Boilers (Part 6)—A. N. Diehl, Apr., 1916, p. 170.

Continuing the investigation of blast furnace gas burning conditions with a set of test figures to show efficiencies to be expected and obtained.

Modern Methods of Using Blast Furnace Gas Under Stoves and Boilers (Part 7)—A. N. Diehl, May, 1916, p. 213.

Closing the presentation of a paper covering the use of blast furnace gas as a fuel for stoves and boilers. Summarizing results and test for burner recommendatioss.

Stack Gas for Boilers and Hot-Blast Stoves (Part 1)—A. N. Diehl, Nov., 1915, p. 989.

Discussing minutely the adaptation of various burner and stove conditions which may or may not make for economical combustion of blast furnace gas.

Blast Furnace Gas in Steam Production—S. M. Marshall, Apr., 1915, p. 506.

Possibilities in bettered boiler efficiencies with more accurate burner manipulation and discression of variation caused by furnace operation with new burner description.

Dry-Hot vs. Cold-Wet Furnace Gas Cleaning—Linn Bradley, H. D. Egbert, W. W. Strong, Mar., 1917, p. 104.

Comparing the efficiencies secured and losses sustained through using both of the methods for purifying furnace gases of entrained dust. Recommendations for process.

Economies Effected by Washed Stack Gas—Charles C. Lynde, Sept., 1916, p. 462.

Improving economy and obtaining better running periods with blast furnace gas burning equipment through the use of modern working and drying units.

Combustion of Wrought Iron in Gases—F. W. Harbord, Dec., 1916, p. 556.

Wrought iron tubes suspended in blast furnace gases at moderately low temperatures were found to scale away and permit the formation of black deposits. Hypotheses offered.

Burner Shifts to Meet Varying Conditions—

Charles C. Lynde, Aug., 1916, p. 365.

Effect of Moisture Upon the Flame Temperature of Blast Furnace Gas—S. E. Eldridge, Nov., 1913, p. 26.

Operation.

Stocking and Charging a Merchant Furnace—Charles C. Lynde, Apr., 1915, p. 416.

Innovations in operating practice at plant of the Stewart Iron Company, Sharon, Pa., planned with a view to economical operation of an isolated unit.

Heat Losses in Furnaces—F. A. J. Fitzgerald, Aug., 1913, p. 46.

Economy in Use of Blast Furnace Carbon—H. P. Howland, May, 1916, p. 219.

Data to be secured to check blast-furnace coke consumption and methods for securing same. Influence of gas sampling. Relation between wind, coke and production.

Uses of Extra Coke on the Blast Furnace—Wallace O. Imhoff, Jan., 1916, p. 13.

Enumeration and classification of the need for more than the theoretical smelting amount of coke on the burden of the working stack. Operating for coke savings.

Stack Rehabilitation for Alloy Output—Chas. C. Lynde, May, 1915, p. 500.

Old plant running on ferrosilicon burden. Bessie furnace at New Straitsville, O., a type of single-stack installation which is giving good operating results.

Stock Lines and Top Considerations. May, 1915, p. 514.

Recording burden level in working furnace under all conditions of operation. Value of mechanical filling bar. Larger stacks demonstrated in actual practice.

Effect of Wet Ore on Charcoal Furnace Practice. Dec., 1915, p. 1,060.

Recent Blast Furnace Advancement—A. E. Maccoun, June, 1915, p. 592.

Factors contributing to improvements in stack practice as developed in latest methods of use. Value of hot blast in successful furnace campaign. Stove influence.

Recent Blast Furnace Advancement (2)—A. E. Maccoun, July, 1915, p. 670.

Factors contributing to improvements in stack practice as developed in latest methods in use. Value of hot blast to successful furnace campaign. Stove influence.

Recent Blast Furnace Advancement (3)—A. E. Maccoun, Sept., 1915, p. 844.

Factors contributing to improvements in stack practice as developed in latest methods in use. Value of hot blast to successful furnace campaign. Stove test figures.

Recent Blast Furnace Advancement (4)—A. E. Maccoun, Oct., 1915, p. 915.

Factors contributing to improvements in stack practice as developed in latest methods in use. Value of hot blast to successful furnace campaign. Test data.

Cause of Vibration in Cold Blast Mains. Nov., 1915, p. 1,010.

Practical consideration of features in blast delivered by reciprocating engine-blowing plants which cause disturbances in mains. Mechanical means for damping trouble.

Service Data on the Brown Furnace Top—K. L. Landgrebe, July, 1916, p. 329.

Mechanical features introduced into standard top design to adapt it to local conditions. Results obtainable with slight changes in layout.

How Tuyeres Indicate Furnace Conditions—Wallace G. Imhoff, July, 1916, p. 326.

What the various changes taking place in the furnace look like and how their correct interpretation aids in controlling furnace operations.

Trend of Modern Blast Furnace Practice. Feb., 1915, p. 164.

Driving Furnace With Increased Blast Heats—Walter Mathesius, Mar., 1915, p. 279.

Securing economy and long operation with higher blast temperatures for melting Mesaba ores. Value of cleaned gas and its effect on stove capacity. Methods of burning gas.

Measurement of Hot Blast Main Heat Losses—R. J. Wysor, Dec., 1915, p. 1,041.
Influences of cooling effect of hot blast mains brought out by measurement of temperature drop between stove and stack temperatures. Need for adequate insulation demonstrated by figures.

Electric Skip Hoists for Blast Furnace Use—H. D. James, Feb., 1917, p. 71.

Design characteristics of ac. and dc. motors when used for skip control. Obtaining accurate slow-down and stop without adding excessive apparatus to installation.

Air Drying Methods for Blast Furnaces—Leon Cammen, May, 1917, p. 216.

Cryogenis and chemical means for drying blast considered. One type of process which gives large volumns at relatively low production cost. (Description.)

Adding Stack Capacity. Oct., 1914, p. 5.

Modern American Blast Furnace Practice—Herman A. Brassert, June, 1914, p. 5.

Modern American Blast Furnace Practice—Herman A. Brassert, July, 1914, p. 16.

Modern American Blast Furnace Practice—Herman A. Brassert, Aug., 1914, p. 46.

Modern American Blast Furnace Practice—Herman A. Brassert, Oct., 1914, p. 42.

Conservation of Blast Furnace Flue Dust. Jan., 1914, p. 14.

Utilization of Blast Furnace Flue Dust. Jan., 1914, p. 11.

Prevention of Tuyere Breast or Bosh Breakouts. Dec., 1917, p. 573.

Resulting Reactions of Superheating Slags—J. E. Fletcher, Dec., 1917, p. 549.

Consideration concerning the superheating of slags and metals during refining, smelting and alloying operations. Graphical representation of these reactions.

Lime as a Compound of Furnace Slag—Wallace O. Imhoff, Sept., 1917, p. 411.

Classification of lime features distinguishing lime. Hot furnace from lime cold furnaces. Properties of cinder indications of furnace conditions.

Stoves.

Late Progress in Hot Blast Stove Design—Arthur J. Boynton, Nov., 1916, p. 508.

Summarizing the betterments in stoves and presenting operating data, showing wherein the changes have proved beneficial. First part of institute paper.

Late Progress in Hot Blast Stove Design (Part 2)—Arthur J. Boynton, Jan., 1917, p. 19.

Concluding paper presented partially in November issue, listing and describing the important changes in stove structure and design. Insulation for heat saving.

Discussion of Hot Blast Stove Design—R. J. Wysor, Nov., 1916, p. 507.

Hot Blast Stove Efficiency—John J. Porter, Mar., 1913, p. 9.

The Heat Balance of Hot Blast Stoves. July, 1193, p. 42.

Radiation Losses of Hot Blast Stoves. Aug., 1913, p. 32.

Modern American Blast Furnace Stoves. Feb., 1915, p. 141.

A German view of American types, with some criticism based on tests abroad. Question of combustion efficiencies raised in the light of German experiences. Comment on the two-pass and three-pass design.

High Temperature Insulation and Control—P. A. Boeck, Feb., 1916, p. 61.

Reduction of heat losses at hot-blast stoves, mains, stacks and other points in furnace plant requires special insulation. Herein is information on this point.

Horizontal Blast Furnace Stoves. Mar., 1915, p. 274.
Suggestions on ease of erection, with operation characteristics in the horizontal type. Contracts in vertical and horizontal stove efficiencies, as outlined by a German authority.

Suggestions Regarding Construction of Hot Blast Stoves. Mar., 1917, p. 126.

High Rate of Heat Transmission in Blast Furnace Stoves. Apr., 1914, p. 22.

New Three-Pass Hot Blast Stove. May, 1914, p. 20.

BY-PRODUCT COKE

Coefficient Curves for Stack and Oven Gas—Thomas G. Estep, Jr., Apr., 1917, p. 147.

Presenting further discussion of the orifice method of measuring gas volumes. Curves given for blast furnace and coke oven gas to simplify measurements.

Coke in Blast Furnaces—C. J. Ramsburg and F. W. Sperr, Jr., Nov., 1917, p. 536.

Determination of Coke Oven Heat Balance. Dec., 1915, p. 1,034.

Combustion Notes on Blast Furnace Coke—Herman A. Brassert, Sept., 1915, p. 834.

Wherein particular references is made to the combustibility of furnace fuel. Influence of by-product on burdening conditions at stack. Physical and chemical factors of weight.

The Value of Coke.—R. Rollins, May. 1914, p. 13.

By-Products of Coke Oven Instalation. July, 1917, p. 333.

By-Product Coke Oven Pressure Regulation—W. Trinks, Oct., 1917, p. 461.

Theory and operation of a by-product coke oven pressure regulator with a discussion by the manufacturer of the regulator in question.

Data Concerning Typical By-Product Coke Oven Installation. Sept., 1917, p. 428.

Iron Coke. Jan., 1917, p. 34.

Compression of Coal in By-Product Coke Operations in Scotland. Mar. 1915, p. 294.

By-Product Plant at Sheet & Tube Works—Charles C. Lynde, Jan., 1917, p. 1.

New by-product coke plant of the Youngstown Sheet & Tube Company, recently completed, contains many means for expediting materials handled with dual units.

Effects of Benzol Process on Coke Oven Gas. Apr., 1915, p. 438.

Sulphur Elimination in By-Product Coking—C. C. Campbell, Aug., 1916, p. 368.

Wherein is shown the influence of sulphur upon the quality of coke and by-products obtained from rain coal. Inadequency of water as desulphurizing agent.

By-Products Recovery in Coke Production—W. H. Childs, June, 1916, p. 277.

Utilizing the ammonia and gas yielded during the coking of coal. Uses and value of these important elements formerly wasted and their application to steel works conditions.

The Utilization of Coal Tar Pitch. Dec., 1916, p. 580.

By-Product Coke in the United Kingdom. Dec., 1917, p. 582.

New By-Product Coke Ovens. Dec., 1917, p. 582.

Practical Limits of Coke Quality. Dec., 1917, p. 582.

By-Product Coke Oven Pressure Regulation—C. H. Smoot, Nov., 1917, p. 503.

Adjustment of valve openings to correct for variation of exhaust suction more important than correcting variations in gas volume. Stabilizing feature improves regulation.

Attention is called to the fact that "The Blast Furnace and Steel Plant" maintains a regular department relative to this subject. The articles in this department are not tabulated in this index.

CONSTRUCTION AND DESIGN OF STEEL PLANTS

Crane Handling for Sheet Mill Products—Charles C. Lynde, Apr., 1916, p. 165.

Layout and equipment at Canton Sheet Steel Company's plant to provide for elimination of hand trucking. Crane haulage used in production department.

Breaking Out Large Boulders. May, 1915, p. 570.

Doubling Bridge Capacity on Old Piers—Charles C. Lynde, Apr., 1915, p. 468.

Ohio connecting bridge across Ohio river below Pittsburgh made double-track structure without adding to foundation work. Train operation provided over one line at all times. Type of top-chord traveler used on spans.

Completing Heavy Work on Railroad Job. Apr., 1915, p. 471.

Meeting construction problems introduced by taks of building new line along old tracks without disturbing traffic. Handling spoil from heavy cuts and tunnel work. Provisions for labor on 12-mile stretch of contract.

Moving Stocks at Supply and Field Depots—Charles C. Lynde, Mar., 1915, p. 331.

Types of equipment found most economical for unloading tonnages of building materials. Concentrating all lifting in one hoist and utilizing gravity as distribution force.

Design of Structure for Open Hearth Use—C. A. Randorf, Oct., 1916, p. 469.

Taking a large open hearth building and setting forth the points where the severe service demands extra strength or special handling. Provisions for safety.

Grab Buckets for Difficult Handling Jobs—Edgar E. Brosius, Sept., 1915, p. 827.

Use of various bucket types for moving open hearth and converter slag, mill scale, cinder and other stubborn materials. Illustrations of plants and their handling problems.

Recent Progress in Corrosion Resistance—Daniel M. Buck, June, 1915, p. 582.

Methods now in vogue for retarding and wasting of iron and steel under the effect of air and water. Relative values of types.

Catenary Reinforced Concrete Flume—H. M. Gibb, May, 1915, p. 562.

Flexible structure designed and constructed to provide for carrying of load under simple tension in material. Trestles used in place of arches as supports.

Crane Adaptation for Open Hearth Work. Mar., 1915, p. 278.

Bringing the craneman closer to his work by extending cab. Better control. Safety also.

Plant Building for the Future—Charles C. Lynde, Oct., 1914, p. 12.

Compressed Air Concrete Handling. May, 1915, p. 569.

Protecting Bridge Members from Corrosion. Mar., 1915, p. 334.

Outline of the causes of failures through corrosion with comparative results obtained from different coverings for steel in exposed locations. Necessity for blast plates where locomotive exhaust is to be met.

Office Frills in Design of Reinforced Concrete—Edward Godfrey, May, 1915, p. 560.

Reasons why the "patented" design had found entrance into the latest types of building construction even as it flourished in bridge building in the early days.

Strength Tests of Reinforcement Types. May, 1915, p. 557.

Consistent results from experiments. Relative values of each type.

Structural Members as Concrete Stiffener—Charles C. Lynde, May, 1915, p. 554.

Adaptation of steel for reinforcement in counterparts of canal lock walls. Saving of material thus affected and construction problems solved.

A Resume of a Discussion on Reinforced Concrete Design—Edward Godfrey. Apr., 1915, p. 476.

Mr. Godfrey's reply to arguments in favor of present standard methods of reinforcement before American Concrete Institute. Accepted design of rodded column and stirruped form of reinforcement as against hooped and anchored steel in concrete.

Foundation Problems in Bridge Work. Apr., 1915, p. 474.

Construction of twin caisson piers with structural steel truss reinforcing upper reinforcing upper head of connected piers. Protection of bridge against collision damage. Removable booms solve ice question.

Laying Cable in Steel Plant—F. D. Egan, Oct., 1914, p. 16.

Destruction of Concrete Foundations (By Chemical Action). Apr., 1917, p. 174.

Fitted Cast Iron Floors in Machine Shops. Feb., 1915, p. 149.

Care of Hoisting Cables. Feb., 1915, p. 165.

Heating Units for Large Plant Buildings. Apr., 1915, p. 430.

How power plant exhaust is utilized at the works of the Mesta Machine Company. Pittsburgh; a description of the ventilating duct system.

Difficult Moving of Concrete Building. Mar., 1915, p. 347.

Transportation of structure over varying grades and around several curves from original location to new site. Details of track and rollers for long move.

Critical Review of Current Codified Concrete Construction Practice. Mar., 1915, p. 342.

Discussion of various plants in present building regulations with illustrations of certain failures of theoretically correct structures. Faults in design that still persist.

Business Methods in Construction Work—James L. Stuart, Apr., 1915, p. 467.

Erection Traveler for Large Bridge Job. Mar., 1915, p. 337.

Type of equipment used in construction of new Quebec bridge. Principal features and limitations imposed by design of structure. Operation in field.

Wooden Roof Trusses. Oct., 16, p. 490.

DUPLEX PROCESS

Size and Design of Hot Metal Mixers. Oct., 1915, p. 932.

Duplexing as Practiced at Lackawanna—George E. Waterhouse, Nov., 1916, p. 514.

The process as followed at the plant of the Lackawanna Steel Company. Plant revisions and operation schedule adopted for expediting process conditioning apparatus for work.

Iron Desulphurization in Mixer Operation. Aug., 1916, p. 363.

In which are presented German operating conditions as of importance in mixer design and driving. Desulphurization as a mizer function.

Duplexing Conditions in Steel Production—F. F. Lines, Aug., 1915, p. 746.

Modifications of original duplex process as used at plant of Maryland Steel Works. Comparison of four methods passable under plant restrictions. Results obtained at unfavorable periods.

Steel Production by the Duplex Process—L. K. Furst, Sept., 1917, p. 390.

Construction and arrangement of duplexing plant. Consideration of methods of operation. Description of equipment and hot metal mixers.

Steel Production by the Duplex Process—L. K. Furst, Oct., 1917, p. 458.

The second of a series of articles concerning duplexing, which describes the construction and operation of the converters and open hearths.

Discussion of Duplexing—Quincy Bent and T. W. Robinson, Nov., 1916, p. 503.

ELECTRICAL APPLICATIONS IN THE STEEL INDUSTRY

Operation of Grab Bucket Coal Hoists—James Farrington and R. H. McClain, Nov., 1917, p. 507.

Alternating current motors with dynamic braking and regenerative braking. Ac and dc installations compared with regard to most important features.

Vibration of a Turbo Generator by Resonance. June, 1916, p. 96.

Ore Transportation in Chile. Feb., 1917, p. 78.

Electric Motor Drive for Bell Hoists. Feb.. 1917, p. 74.

Electrically Powered Sheet Mill Operation—Charles C. Lynde, Mar., 1916, p. 121.

Unique features of Western Reserve Steel Company's plant at Warren. Speeding up sheet production by simplifying work and shortening intervening distances.

Electric Skip Hoists for Blast Furnace Use--H. D. Sannes, Feb., 1917, p. 71.

World's Largest Self-Cooled Transformer. July, 1917, p. 346.

Pusher Car. July, 1917, p. 346.

Heavy Duty Electric Motors. Aug., 1917, p. 892.

Electrical Operation of Bloom Shears—G. E. Staltz, Sept., 1917, p. 408.

Overcoming the problem of clutch design on large bloom shears by omitting the flywheel and utilizing a direct-current motor coupled directly to the shear.

Magnetic Shielding of Large Spaces. Dec., 1916, p. 580.

Purity of Platinum Ware. Aug., 1915, p. 766.

Electrical Development in the Steel Industry—A. G. Ahrens, Oct., 1917, p. 437.

Brief review of recent developments and applications of electricity in refining and rolling steel. Shows tremendous increase in the use of electric power in mills.

Electric Drives for Reversing Mills—D. M. Petty, Oct., 1917, p. 464.

Reversing mill drives considered from standpoint of cost of equipment, efficiency and reliability. Description of operation of this type of drive.

Electric Hoists for Blast Furnaces. Apr., 1917, p. 174.

Use of X-Ray for Testing Steel. Apr., 1915, p. 438.

Frame Vibration Responsible for Commutator Trouble. May, 1917, p. 225.

Electric Towing Locomotives at Panama. Feb., 1915, p. 180.

Problems worked out in devising of a new type motive power unit for service at Panama. Unique details of design required in locomotives finally accepted and installed at the locks. Operating features and necessary safeguards against breakdowns of towing system. Successful trials at the locks.

Late Development in Electrical Equipment—K. A. Pauly, Oct., 1915, p. 901.

Problems met by steel mill electrical engineer in adapting modern power unity to the needs of his industry. Systems for governing speeds of induction motors over considerable ranges.

Control of Steel Mill Electric Hoists—G. E. Stoltz and W. O. Lum, Apr., 1915, p. 512.

Factors entering into control layouts of direct current equipment on blast furnace skips in rolling mills. Consideration of load. Stopping facilities.

The Trend of Electrical Development—P. M. Lincoln, Aug., 1915, p. 803.

Survey of field with forecast of future possibilities in power equipment. Relation between cost and temperature of machine. Several steady improvements to be expected.

Control of Electric Motors in Steel Mills—H. F. Stratton, Dec., 1916, p. 567.

The operation of mechanically connected direct-current motors permanently in series or permanently in paralel. Diagrams and graphs showing characteristics and connections.

Central Station Steel Mill Electrification—Brent Wiley and Wilfred Sykes, Oct., 1915, p. 905.

Operation characteristics of steel mill electrical equipment with their relation to the offerings of central station power plants as against localized generating units.

Using the Electric Arc in Foundry Practice—Robert E. Kinkead, Oct., 1915, p. 961.

Various means whereby this modern source of auxiliary heat may be utilized to advantage in solving casting problems, reclaiming effected. A valuable asset in process.

Emergency Starting Rheostat. Feb., 1916, p. 96.

Parallel Packing of Nails by Electricity. Apr., 1916, p. 184.

Removing Generator Dust. Apr., 1916, p. 184.

Loading Pig Iron with Electro-Magnets. July, 1916, p. 340.

Costs vs. Upkeep of Direct-Current Motors—A. M. MacCutcheon, Oct., 1916, p. 478.

In which the author dissects a typical motor and evaluates the percentage cost of each improvement and also catalogues the betterment to be expected.

Electrically Driven Hoppers for Coke Ovens. Oct., 1916, p. 490.

Cost vs. Upkeep of Direct-Current Motors—A. M. MacCutcheon, Nov., 1916, p. 524.

Concluding the presentation of a typical motor and the evaluation of percentage increase in cost for added refinements. Total increase over normal cost.

Electric Reversing Blooming Mills—Ralph D. Nye, Dec., 1917, p. 566.

Electric Power Economy Factors—Brent Wiley, Nov., 1917, p. 514.

Rapid increase in the scope of application of electric power makes its generation an important question from the standpoint of economy.

ELECTRIC FURNACES

Application.

The Manufacture of Steel Castings—Robert P. Lamont, June, 1917, p. 247.

Development in this country of the art of forming large castings. Problems of design and treatment briefly sketched in the light of modern practice in large shops.

Electric Steel Refining. Nov., 1915, p. 1,016.

Electric Furnace in Steel Manufacture—John A. Mathews, June, 1916, p. 260.

The use and scope of electric furnace for the manufacture of high grade steel. Field compared with that of crucibles. Types and their application.

Electric Furnace Heat Treatment of Steel—Thaddeus F. Bailey, Nov., 1915, p. 1,037.

Reviewing the possibilities of the automatic electric furnace unit for producing the accurate temperature regulation prescribed for special steel. Advantages to be expected.

Electric Steel Tests. Oct., 1916, p. 492.

Electric Iron Ore Smelting. June, 1915, p. 598.

Electric Smelting in New Zealand. Apr., 1917, p. 174.

Electric Furnace in Making Special Steel—Charles C. Lynde, May, 1917, p. 214.

Installation of furnace for producing steel of widely varying grades. Method of electrical control for any combination of series and parallel electrode use.

Electric Furnace Value on Production of Liquid Ferromanganese. Feb., 1915, p. 145.

Experiments to fix economical working conditions in steel making where premelting is advisable. Types of apparatus used and comparative efficiencies. Usual manganese losses.

Description

Smelting Pig Iron in the Electric Furnace—Robert Turnbull, Nov., 1917, p. 502.

Shell turnings used as charge. Charcoal coke or coal for carbon base. Power shortage offers chief obstacle. Opportunity for cheaper production of low phosphorus pig iron.

Laboratory Electric Furnace. Feb., 1911, p. 163.

Frick Induction Furnace at Krupp Works. Dec., 1913, p. 34.

Greaves-Etshells Electric Furnace—A. M. Staehle, Oct., 1917, p. 454.

English furnace recently introduced into this country. Uniform product and constant circulation secured by convection currents set up by bottom heating.

The Snyder Electric Furnace. Mar., 1915, p. 295.

Operation.

Melting Alloys in an Electric Furnace Unit—R. S. Wile, Dec., 1915, p. 1,050.

Thermo-Electric Determination of Critical Points of Iron. Jan., 1917, p. 34.

Causes for High Electrode Consumption in Electric Furnace Practice, July, 1917, p. 333.

Operation of Heroult Electric Furnace—Walter C. Kennedy, Oct., 1917, p. 467.

Operating characteristics. Voltage relations for various currents. Vector diagrams for power factor and losses. Consideration of skin effect of the conduction.

Electric Furnace Operation. Apr., 1917, p. 176.

Melting Characteristics of Electric Furnace. Feb., 1916, p. 96.

Electric Furnace Central Station Supply—Edwin L. Crosby, Nov., 1917, p. 521.

Central station anticipating electric furnace business should prepare to discuss the electrical and metallurgical characteristics of various types of furnaces with the buyer.

FORGING

1,000-Ton Hydraulic Forging Press. Feb., 1915, p. 187.

Electrifying the Forge Shop. Sept., 1915, p. 897.

Relative Methods of Forming Steel: Pressing, Hammering or Rolling—John Lyman Cox, June, 1917, p. 252.

Comparative data on effectiveness and quality of product in armanent and other heavy work, with hammers and presses. Limitations of each process under present American practice.

Locating Die Room: Protective Covering for Furnace Doors. Dec., 1915, p. 1,105.

Handling Scrap at Hammers. Aug., 1915, p. 821.

Swabbing or Spraying Dies. Aug., 1915, p. 821.

Gang Production of Gear Blanks: Revolving Heavy Work. Oct., 1915, p. 979.

Using Furnace Heat Twice: Pre-Heating Deep Drawing Dies. Nov., 1915, p. 1,062.

Turning Stock During Hammering. Feb., 1917, p. 76.

Forge Shop Production Methods—Charles C. Lynde, June, 1915, p. 633.

Causes of "Ghost Lines" in Large Forgings—J. O. Arnold, Jan., 1916, p. 5.

An investigation into causes and nature of the phenomena observed in many large steel forgings. Effect of phantom lines on structure and quality of piece.

Metal Stampings: Lubricating Stock for Automatic Machine Conveyors for Finished Work. Dec., 1915, p. 1,102.

FUELS

Blast Furnace Gas.

Stack Gas for Boilers and Hot-Blast Stoves (Part 1)—A. N. Diehl, Nov., 1915, p. 989.

Discussing minutely the adaptation of various burner and stove conditions which may or may not make for economical combustion of blast furnace gas.

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Combustion of Wrought Iron in Gases—F. W. Harbord, Dec., 1916, p. 556.

Wrought iron tubes suspended in blast furnace gases at moderately low temperatures were found to scale away and permit the formation of black deposits. Hypotheses offered.

Coefficient Curves for Stack and Oven Gas—Thomas G. Estep, Jr., Apr., 1917, p. 147.

Presenting further discussion of the orifice method of measuring gas volumes. Curves given for blast furnace and coke oven gas to simplify measurements.

General.

Artificial Gas for High Temperature Work—E. Raven Rosen and Baum, Dec., 1915, p. 1,080.

The application of artificial gas to industrial uses of high temperatures. Presentation of illuminating gas side of much disputed question.

Mixing Blast Furnace and Coke-Oven Gas. Feb., 1917, p. 76.

Flame Length as Factor of Gas Burning—Frederick Peiter. Apr., 1916, p. 172.

Analyzing various combustion conditions with data and proposing some solutions of gas burning problems. Influence of flame length shown herein.

Fuels Available for Metallurgical Furnaces. Jan., 1917, p. 26.

Considering the various fuels which may be used in metallurgical operations. Limiting each according to distribution and available amount. Ideal fuel yet to be found.

Offices for Gas Volume Testing: Effect of Oxygen in Strengthening Irons: Corrosion of Iron Machinery: Measuring Gases by a Standard Orifice—Thomas G. Estep, Jr., Jan., 1917, p. 15.

Charted Analyses of Bituminous Coal—F. Denk, Aug., 1915, p. 799.

Methods whereby approximate and ultimate analysis figures on various fuels may be secured within narrow margins without necessitating long and expensive operations. Value to users.

Bureau of Mines' Work for Smokeless Combustion and Fuel Efficiency. Feb., 1915, p. 228.

Combustion tests at the Pittsburgh laboratories. Heat transmission investigations. Gas producers work to be undertaken.

Reduction of Fuel Variation at Burner. Feb., 1915, p. 161.

Combustion demands of various fuels. Attempts to reduce number of regulation points in system. Storage type of gas and air mixer. A machine for furnishing proper mixture only as needed.

Coal Handling for Efficient Distribution. Apr., 1915, p. 425.

Central distribution system for fuel at plant of Brier Hill Steel Company affords unusual facilities for easy storage and accessibility of supply.

Utilization of Blast Furnace Gas—H. F. Freyn, Mar., 1914, p. 10.

Use of Gas for Various Heating Purposes. Feb., 1915, p. 163.

Compares oil, gas and coal for various uses.

Formulae for Finding Large Gas Volumes—H. G. Geissinger, Feb., 1917, p. 55.

Discussing Prof. Estep's "Measuring Gases by a Standard Orifice" appearing in January, offering some simplified expression for finding constant used.

Producer Gas.

Maintaining Gas Producer Air-Steam Ratio—Frantz Denk. Dec., 1915, p. 1,039.

Importance of maintaining exact proportions between draft and steam admitted under producer grate. Blower types as fitted for such service. Losses from incorrect driving.

Operating Characteristics of Gas Producers—Franz Denk, Apr., 1916, p. 177.

Closing a series of papers on various phases of gas producer operation and economy. Summarizing the points to be watched to secure efficient running and good gas.

Operating Characteristics of Gas Producers—Franz Denk, May, 1916, p. 240.

Theoretical temperatures to be found with various types of combustion of gas and air. Applicability of such figures to practice with allowance for furnace losses.

Separate Air and Steam for Gas Producers—Franz Denk, Jan., 1916, p. 23.

A consideration of the advantages to be gained in gas-producer operation through the blowing of blast air and steam separately by mechanical means as against jet action.

Setting a Fair Base for Producer Efficiency—Frank Denk, Feb., 1916, p. 86.

Calculations covering another fuel loss in producer operation. Need for figuring operating power into efficiency balance to obtain true economy.

Coal and Ash Transportation at Producers—H. V. Schiefer, May, 1917, p. 199.

Eliminating the human factor in the handling of coal and ashes to steel mill producer plant. Automatic weighing and measuring device as check on fuel used.

Gas Producer Economy from Fuel Factors—Frantz Denk, Nov., 1915, p. 998.

Analysis of operation of producers continued from last month in further discussion of gasification characteristics under conditions of fueling and use.

Factors Governing Gas Producer Practice—Frantz Denk, Oct., 1915, p. 911.

Analysis of operations and gasification characteristics of gas producers.

Pulverized Coal.

Pulverized Coal as Fuel. Mar., 1917, p. 128.

Pulverized Coal as a Metallurgical Fuel—James W. Fuller, Nov., 1916, p. 519.

Metallurgical furnaces area exacting in the type of fuel they use and the fuel field is gradually narrowing. Treatment of coal for economical and effective use.

Discussion of Powdered Fuel—W. A. James, J. P. Kittredge and N. C. Harrison, Nov., 1916, p. 505.

Powdered Coal as a Blast Furnace Fuel. July, 1916, p. 315.

Boosting the furnace by blowing pulverized coal into the tuyeres. High heats possible with very little change in existing stack equipment. Coke reduction secured.

Pulverized Coal as Fuel. Aug., 1914, p. 13.

Dust Explosions. June, 1917, p. 285.

Oil.

A New Method of Burning Crude Oil—W. K. Janssen, Dec., 1917, p. 569.

Oil is classified in a specially designed vaporizer outside the furnace and forced into combustion chamber under positive pressure.

HEATING FURNACES

Design.

Standardization of Air Furnace Operation—A. L. Pollard, Oct., 1915, p. 956.

Design and construction of modern malleable foundry accessory, labor and operations and difficulties in present types. Methods whereby betterment may be secured.

Surface Combustion Laboratory Furnace. Dec., 1916, p. 561.

Steel Making and the Wills Combination Furnace. Dec., 1913, p. 24.

Obtaining Extra High Temperatures. Jan., 1917, p. 38.

Proper Heating Furnace Insulation. May, 914, p. 38.

High Pressure Gas for Heating Furnaces. Nov., 1915, p. 1,018.

Operations.

Smokeles Operation of Heating Furnaces. Mar., 1917, p. 128.

HEAT TREATING

Gearing Development Through Treatment—W. H. Phillips, Apr., 1917, p. 152.

Showing how the development of heat treating as perfected for automobile gears can add to the life and service of rolling mill gear trains and increase efficiency.

Recent Development in Heat Treatment of Railway Gearing—W. H. Phillips., Feb., 1915, p. 251.

Evaluation of railway motor gears, from cast iron to heat-treated alloy steel. Cast and forged blanks compared. Treatment of rim and teeth and accompanying difficulties. Something about alloys.

Relation of Heat Treatment to Stress Resistance. Mar., 1915, p. 291.

Finishing Temperatures of Rails. July, 1915, p. 692.

Effect of Hardening Upon Shape and Dimensions of Steel. July, 1915, p. 690.

The Influence of Temperature on the Physical Properties of Metals. Mar., 1916, p. 134.

Annealing Rolls Weighing Four and Five Tons. Sept., 1917, p. 414.

Electric Furnace Heat Treatment of Steel—T. F. Baily, Nov., 1916, p. 1,037. (See Electric Furnace.)

INDUSTRIAL SAFETY

Safety and the Unfit. Feb., 1915, p. 188.

Shop Signals. Sept., 1916, p. 434.

Safe Practice in Mill and Factory. Feb., 1915, p. 195.

Safe Practice in Mill and Factory. Feb., 1915, p. 178.

Use of portable hoistings and conveying units for reducing number of men within danger zone. With bettered safety factors in lifting mechanisms. Steel mill considerations. Questions discussed at meeting of Pittsburgh section, National Safety Council on the evening of February 5.

Device for Detecting Gas. May, 1917, p. 225.

Safe Practice in Use of Chains and Ropes. Aug., 1917, p. 376.

Ozone for Plant Ventilation. Aug., 1915, p. 768.

First Aid to Electric Shock Victims—William C. L. Elgin, June, 1915, p. 651.

Things to be done at time of accident to prevent lapse of respiratory organs. Resuscitation methods compared.

Safety Specifications for Cranes. Mar., 1915, p. 293.

Dangers from Gas—R. J. Young, Aug., 1914, p. 12.

Wage, Employment, Safety, Welfare. Feb., 1915, p. 169.

Comparison Basis for Illuminants. Dec., 1916, p. 580.

Investigation of Injurious Dusts in Steel Works. Sept., 1917, p. 419.

Safeguarding Electric Cranes—J. C. Smith, Dec., 1917, p. 577.

INGOTS

Solidifying Influence of Aluminum on Ingots. Apr., 1914, p. 40.

Dual Pouring of Ingots. July, 1916, p. 342.

Dual Pouring of Ingots—George E. Thackray, Sept., 1916, p. 420.

Production of Sound Steel for Rails—Sir Robert A. Hadfield. Mar., 1915, p. 282.

An important paper before Franklin Institute, discussing measurement of piping and cavities in steel and determination of extent of unsoundness. Necessity of thorough inspection of all ingots. Importance of preserving ferrostatic pressure.

Ingot Pouring Device Reduces Piping—A. M. Staehle, Sept., 1917, p. 399.

Quadruple method of pouring ingots developed at the Brier Hill Steel Company's plant at Youngstown, O., has given good results in reducing piping.

Causes of Steel Ingot Defects—J. N. Kilby, July, 1917, p. 301.

Defects classified as pipes, segregation, occluded slag, fluxed fireclay, laps and cracks. Advantageous methods of pouring and advantages of various types of moulds.

Crystallization of Steel Ingots—J. F. Keller, Oct., 1917, p. 455.

Factors influencing crystallization of ingots. Diagrammatic representation of formation of structure. Effect of reheating, soaking and rolling.

Piping Hot. April, 1917, p. 154.

Control of Ingot Piping and Segregation—Henry M. Howe, Nov., 1915, p. 993.

A definition of the principles underlying these causes of failure of the steel while still in the ingot mould. Novel experiments calculated to verify author's inferences on phenomena.

Service Test of Hadfield Cast Ingots. Mar., 1915, p. 292.

The Sound Steel Ingot. Mar., 1913, p. 16.

Temperature Influence on Steel Ingots—J. W. Haulman, Nov., 1917, p. 524.

IRON ORES

Developing Iron Bearing Materials Sinter—Bethune G. Klugh, Nov., 1915, p. 984.

Mechanical improvements over original devices for producing sinter from flue dust, ore fines and other material unfit for blast furnace charging in its natural state.

Developing Iron Bearing Materials Sinter—Bethune G. Klugh, Dec., 1915, p. 1,037.

Conclusions of paper covering improvements and changes in sintering practice and machines.

Iron Ore Mined in 1916. Sept., 1917, p. 415.

Experiments on Earth Pressures—P. M. Crosthwaite, Apr., 1917, p. 165.

Relating to ore storage.

Electrical Separation of Furnace Ore Dust—A. F. Nesbit, Mar., 1915, p. 160.

The Iron Ores of the Marklesburg Region—Wallace G. Imhoff, Dec., 1916, p. 553.

Giving the mineralogical condition of these ores and showing wherein they may be used for blast furnace burden without undue labor or expense. Washing means used at one mine.

Advancement in Underground Ore Loading—M. E. Richards, June, 1916, p. 288.

Features of machines used for loading ores in mines. Types recently developed to eliminate the labor problem in a large measure.

Rotary Kilns for Preparation of Iron Ores—S. E. Doak, Jan., 1916, p. 15.

The utilization of rotary kilns for desulphurization and agglomeration of iron ore fires. Types of kilns best adapted to the treatment of ores. Reduction of pyrites.

Cuban Iron Ore—Francis J. Peck. Mar., 1913, p. 13.

Briquetting Fine Iron Ores. Mar., 1915, p. 293.

New Baker Type of Storage Bin. Nov., 1913, p. 9.

Removing Rings from Nodulizing Kilns. Mar., 1915, p. 291.

Distribution of Manganiferous Ores. Feb., 1915, p. 165.

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The Bontempi Rust-Proofing Process. Jan., 1916, p. 46.

Recommendations for the Preservation of Iron and Steel. Sept., 1916, p. 43.

Micrographic Studies on Copper, Iron and Steel. Feb., 1917, p. 74.

Removal of Rust with Chemical Re-agents—J. Newton Friend and C. W. Marshall, June, 1915, p. 638.

Electrolytic and manual methods of cleaning iron and steel compared with those involving only the use of liquids and dipping of materials.

Effect of Carbon and Manganese on the Corrosion of Steel. July, 1916, p. 342.

Relative Corrodibilities of Gray Cast Iron and Steel. June, 1915, p. 602.

Testing the Durability of Pipe Under Corrosion. Aug., 1916, p. 396.

The Relation of Slag to the Rust Resistance of Wrought Iron. July, 1916, p. 340.

Corrosion of Steel in Water. Nov., 1915, p. 1,018.

Relative Corrosion Periods of Galvanizing Pans. Oct., 1915, p. 934.

Rusting of Iron in Water. Jan., 1917, p. 38.

Manganese Investigations. Dec., 1917, p. 573.

Deoxidation of Steel. Oct., 1916, p. 490.

Graphical Representation of the Sequence of the Various Processes in the Manufacture of Iron and Steel. July, 1917, p. 324.

Sherardizing as a Manufacturing Problem—S. Trood, Oct., 1915, p. 958.

Important points in application of new process to the coatings of iron and steel products. Plans for maintaining purity of zinc dust for uniformity of coatings.

The Carbo-Teredo Treating Process. Nov., 1916, p. 530.

Problems in Use of Liquid Ferromanganese. July, 1917, p. 329.

Crystallization and Structure of Slowly Cooled Steel. Nov., 1915, p. 1,018.

Brittleness in Iron Through Sodium. Jan., 1917, p. 34.

Brittleness in Steel Through Electroplating. Feb., 1917, p. 76.

Colors and Their Bearing on Hardness. Aug., 1915, p. 766.

Wrought Iron and Its Worth—George Schumann, July, 1913, p. 18.

Vanadium—Francis J. Peck, Sept., 1913, p. 32.

Oxygen in Cast Iron—J. E. Johnson, Jr., Feb., 1914, p. 24.

Boiling Point of Iron and Carbon. Sept., 1915, p. 854.

Crystallization of Steel Under Stress. Feb., 1914, p. 16.

Property of Toughness in Metals. Nov., 1913, p. 9.

Properties.

Effect of Chromium in Hardening Steel. Aug., 1916, p. 392.

Crystalline Growth in Strained Ferrite—Kenneth B. Lewis, Sept., 1915, p. 823.

Phenomena observed in low carbon steel which has been stressed and then annealed. Practical establishment of theoretical "Critical Temperature." Value of metalographic study.

An Investigation of the Effect Produced by Varying the Sulphur Content of Basic Open Hearth Steel—Dr. J. S. Unger, Mar., 1916, p. 109.

Wherein are presented findings covering the permissible range of sulphur content and where sulphur in reasonable quantities is not injurious.

Determination of Copper in Alloy Steel—W. D. Brown, Mar., 1915, p. 275.

Chemistry of rapid and accurate method as adapted by United States Steel Corporation. Comparison of results obtained by various methods of determination in several laboratories.

Manganese Significance in Steel Metallurgy—F. H. Willcox, Mar., 1917, p. 97.

Taking up the value of this element as a necessity in steel making. Showing some of the many uses for this alloying and purifying material.

Hardening Theories of Various Steels—E. D. Campbell, Apr., 1915, p. 509.

Conceptions of constitution of steel and changes occurring in variations of hardness. Possible influence of solubility of elements in alloy a factor.

The Influence of Elements in Steel. Nov., 1916, p. 532.

Alumina Inclusions in Steel. Jan., 1917, p. 36.

Sampling and Analysis of Plain Steels. Feb., 1915, p. 163.

Effect of Titanium on Magnetism. Mar., 1915, p. 295.

Oxygen in Steel. Oct., 1916, p. 492.

Use of Titanium in Steel Making. Apr., 1915, p. 524.

Reducing Sulphur Content. Nov., 1915, p. 1,016.

Calorizing Metals. Nov., 1915, p. 1,016.

Microscopic Etching of Steel. Oct., 1915, p. 934.

Electrolytic Iron for Rigid Requirements. Sept., 1915, p. 854.

Coating Iron with Aluminum. Jan., 1917, p. 36.

Use of Alundum in Combustion Method of Carbon Determination. July, 1915, p. 692.

NEWS ITEMS

General.

Government Armor Plate Project is Dropped. Mar., 1915, p. 308.

Congressional commission reports plan impracticable, placing the probable cost at about $10,000,000. Senate recedes from former grounds. Senator Penrose defends position of steel manufacturers.

Smoke Responsibility Cannot Be Individualized—Dr. W. F. M. Goss, Feb., 1915, p. 224.

A new angle of the problem presented by a well-known mechanical engineering authority in a notable address before the Engineers Society of Western Pennsylvania, at its annual banquet last week. What legislation cannot hope to accomplish. Precipitation of smoke particles a separate phase of question. Chicago test.

German Activities in the Iron and Steel Industry. Sept., 1917, p. 415.

Bethlehem Acquires New Plants. Jan., 1917, p. 27.

Sheet and Tin Plate Sliding Scale. Feb., 1915, p. 195.

Independent manufacturers reach agreement with amalgamated association officials for wage agreement for scale based on selling prices. Agreement is subject to referendum vote by union lodges.

The Hardening of Oils. Nov., 1916, p. 530.

Steel Reinforced Aluminum Cables. Feb., 1917, p. 76.

Under Advertising of the Steel Business—George H. Jones, Nov., 1915, p. 1,038.

Readers' Views and Comments from Production Men. Oct., 1915, p. 922.

Now Waiting on the Trade to Make Up its Mind. Nov., 1913, p. 5.

The Forward Swing of the Pendulum in Steel. Feb., 1914, p. 5.

Rail Production Standards. Oct., 1914, p. 28.

The Rapid Decadence in Bessemer Rail Manufacture. Mar., 1913, p. 6.

Typical Results for Year in Western Cities. Feb., 1915, p. 216.

Fiscal Matters. Feb., 1915, p. 170.

Judge Gary on "Indiscriminate Criticism." Mar., 1915, p. 307.

Studies of Human Effort. Jan., 1916, p. 46.

Critisizing the Rittman Gasoline and Benzol Announcements.

Co-operation and the Mobilization of Public Sentiment—John A. Topping, June, 1917, p. 273.

Steel Mine Tie Introduced by Cambria. Mar., 1915, p. 309.

The Structural Steel Situation in Germany in the Fall of 1915. Jan., 1916, p. 46.

Social Insurance in the United States—Miles M. Dawson, Mar., 1915, p. 311.

Official Report on "Ajax" Failure. June, 1915, p. 642.

American Rolling Mill Company Gets Decision in "Ingot Iron" Patent Rights Litigation. Mar., 1915, p. 394.

Publicity and Its Relation to Steel Making—Elbert H. Gary, Nov., 1915, p. 1,006.

The American Manufacturer and the "Made-in-America" Label. Feb., 1915, p. 188.

The Edison Fire and the Engineering Trade. Mar., 1915, p. 340.

Japanese Capital and the Hanyang Iron and Steel Plant—Gardner L. Harding, Feb., 1915, p. 147.

Cleveland's Retiring Smoke Inspector Pleads For Active Co-operation by City Government. Feb., 1915, p. 220.

E. P. Roberts, for three years in charge of Cleveland department. announces his retirement in effect February 1. Lack of co-operation by municipal administration and courts alleged. Review of work for 1914.

Smoke Prevention in the Eastern Cities. Feb., 1915, p. 214.

Pittsburgh's Progress in Smoke Abatement—J. W. Henderson, Feb., 1915, p. 213.

Year's work reviewed in annual report by chief of bureau of smoke regulation. New ordinances in force are liable. Railroads are thanked for willingness to co-operate.

Iron and Steel in the United Kingdom. Dec., 1917, p. 573.

Report of Coke Oven Accidents in 1916. Nov., 1917, p. 523.

Markets and Production.

Price Advances in Wire, Pipe and Sheets. Feb., 1915, p. 209.

Production of Pig Iron for First Half of 1917. Sept., 1917, p. 431.

The Tonnage Prospect for Summer. June, 1913, p. 6.

Firmer Tone in Finished Steel Lines. Feb., 1915, p. 177.

Definite Increase in Tonnage for Week. Feb., 1915, p. 247.

A Low Year for Pig Iron Production Official Totals for 1914. Mar., 1915, p. 305.

Official Production Figures for Pig Iron and Rails in United States, 1914. Apr., 1915, p. 442.

American Shipments of Military Supplies. Mar., 1915, p. 393.

Prosperity in Steel Preached by Farrel. Feb., 1915, p. 210.

Commercial Organizations in Foreign Trade—E. E. Pratt, Mar., 1915, p. 369.

Export Demand Upholds Market. Mar., 1915, p. 389.

Steel Plate Awards for New United States Battleships. Mar., 1915, p. 392.

Social Meetings.

Annual Banquet Engineers' Society of Western Pennsylvania. Feb., 1915, p. 191.

Mechanical Section, Engineers' Society of Western Pensylvania. Feb., 1915, p. 191.

Sixth Annual Safety Congress. Oct., 1917, p. 477.

Fall Meting of Iron and Steel Institute. Nov., 1916, p. 503.

Inspection Tour by Pittsburgh Foundrymen at Mellon Institute of Industrial Research. Mar., 1915, p. 363.

British Iron and Steel Institute Meeting. Oct., 1917, p. 469.

Iron and Steel Electrical Engineers Discuss Problems to Increase Production. Oct., 1917, p. 438.

Vigorous Sessions at Fall Institute Meeting. Nov., 1915, p. 981.

"War Meeting" of Iron and Steel Institute. June, 1917, p. 245.

Iron and Steel Institute Meeting. Nov., 1917, p. 491.

OPEN HEARTH

Description.

The Manufacture of Steel Castings—Robert P. Lamont, June, 1917, p. 247.

Development in this country of the art of forming large castings. Problems of design and treatment briefly sketched in the light of modern practice in large shops.

Characteristics of Regenerators—W. Trinks, Mar., 1914, p. 46.

Shrinkage Crack Causes in Steel Castings—Wm. R. Bossinger, Oct., 1915, p. 955.

Suggestions for overcoming characteristic steel castings defects. Liberal use of chills recommended. Improper overlapping to be avoided. Faulty gating frequent cause of irregularities.

Open Hearth Furnace of Large Capacity—R. H. Trans, Sept., 1917, p. 406.

Compact checker and flue arrangement. Heavy construction and deep bath of a new 150-ton stationary unit of Central Iron & Steel Co.

Lackawanna Steel Company's New Tilting Furnaces. Oct., 1913, p. 7.

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Cooling Exhaust End of Open Hearth Furnace. June, 1916, p. 296.

Checkerwork for Open Hearth Furnace Use—W. A. Jannsen, Nov., 1915, p. 1,004.

Influence of brick shapes and dimensions upon proper working units. Recommendations for changes in furnace and accessories to give more reliable working limits.

Waste Heat Boilers for Open Hearth Furnaces—C. J. Bacon, June, 1915, p. 587.

Economies to be obtained by the use of properly designed equipment to utilize excess heat in stack gases. Furnace improvement.

New Design of Open Hearth Steel Furnaces Using Producer Gas. Mar., 1913, p. 36.

Design of Modern Open Hearth Steel Furnaces. Oct., 1913, p. 36.

Fuels.

Clean Gas for Open Hearth Furnaces—Arthur L. Stevens, Apr., 1914, p. 28.

Blast Furnace Gas for Open Hearth Furnaces. Jan., 1914, p. 34.

Use of Coke Oven Gas in Open Hearth Furnaces. Oct., 1915, p. 932.

Expert Opinions on Gearing Practiee: Burning Tar as Open Hearth Fuel—A. Greiner, July, 1916, ps. 668-669.

Utilization of by-product tar from coke ovens. Increase of pig in furnace charge found necessary after change of fuel supply. Comparison between fuels.

Operation.

An Investigation of the Effect Produced by Varying the Sulphur Content of Basic Open Hearth Steel—Dr. J. S. Unger, Mar., 1916.

Wherein are presented findings covering the permissible range of sulphur content and where sulphur in reasonable quantities is not injurious.

Ferrosilicon in Open Hearth Practice—Archie Smith, Apr., 1915, p. 428.

Critical consideration of methods for introducing ferrosilicon into steel with reasons for selection of furnaces and desirability of having alloy in compact shape.

Information Regarding the Schumann Automatic Reversing Device for Open Hearth

Repairing of Open Hearth Furnace Heads. June, 1916, p. 283.

An interesting repair devised by German steel makers for lengthening the life of open hearth furnace without cutting into production time.

Temperature Measurement in Bessemer and Open Hearth Practice. May, 1917, p. 225.

Bessemer and Open Hearth Temperature Gaging—G. K. Burgess, Mar., 1917, p. 117.

Use of Fluorspar in Basic Open Hearth Practice. Mar., 1915, p. 291.

Comparison of Open Hearth Processes—Dr. Frederick Schuster (Wikowitz). July, p. 20.

Comparison of Open Hearth Processes—Dr Frederick Schuster (Wikowitz). July, 1914, p. 5.

Hot Metal Open Hearth Savings. May, 1916 p. 244.

Care of Leaking Ladle Nozzles. Dec., 1915, p. 1,060.

The Acid Open Hearth Process—F. Rogers, Dec, 1917, p. 545.

Bringing bath to proper condition toward the end of the melting process and use of deoxidizers discussed. Graphical representation of reactions.

Open Hearth Hazards—Leslie M. Rice. Nov., 1917, p. 531.

Gun for Digging Slag from Open Hearth. Nov., 1917, p. 527.

Open Hearth Shield. Nov., 1917, p. 524.

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A 30-Ton Hydraulic Pipe Bender. Feb., 1915, p. 187.

Steel Production at New Minnesota Plant—Charles C. Lynde, June, 1916, p. 251.

Equipping a plant for steel production in northern location. Savings through elimination of ore storage. Operating characteristics as developed during six months' operation.

New Plant of Youngstown Iron & Steel Co.—Charles C. Lynde, Feb., 1916, p. 68.

Electric drive and straight line layout characterize company's new Lowellville plant. Provision for immediate operation and future extension to increase capacity.

Unloader for Frozen Ore and Coal Cars. Feb., 1917, p. 69.

Power appliance developed to give easy unloading of frozen freight without damage to car and with no loss of time. Hopper bottom cars unloaded in few minutes.

The Iron and Steel Industry of Australia—R. A. Field, July, 1917, p. 299.

Location of the iron ore deposits. Some early industries. Steel works of the Brocken Hill Proprietary Company, Ltd., at New Castle, N. S. W.

Studebaker Corporation Gray Iron Foundry—M. R. Kavanaugh, Mar., 1915, p. 366.

Arrangement of department for advantageous handling of cores and castings at South Bend plant. The daily routine at cupola. Precautions in testing. Special processes.

Building a New Plant for Efficiency in Materials Working and Forwarding—Charles C. Lynde, Feb., 1915, p. 153.

Construction features and equipment design for expediting operations in new buildings of Central Steel Company, Massillon, O. Provision for future extension and increased output without increasing rolling mill tables, stands or drives.

Moving a Car Dumper—J. R. Poe. Apr., 1914, p. 32.

Conveyor Provision for Yard Growth—J. R. Poe, Mar., 1914, p. 14.

New Mill of Youngstown Sheet & Tube Co. Sept., 1913, p. 24.

Pneumatic Conveyor for Slack. Apr., 1917, p. 174.

Gears and Pinions for Steel Mill Service—E. S. Sawtelle, Nov., 1917, p. 497.

Tool steel process described. Dissimilar from casehardening in that entirely different ingredients are used in the carbonizing process, giving deeper and more uniform penetration.

Operation of Grab Bucket Coal Hoists—James Farrington and R. H. McClain, Nov., 1917, p. 507.

Alternating current motors with dynamic braking and regenerative braking. Ac and dc instalations compared with regard to most important features.

STEEL MILL POWER PLANTS

Blowing Engines.

Application of Compressor Types. May, 1916, p. 244.

Testing Blowing Engines for Leakage. June, 1913, p. 54.

Reliability of Blowing-Engine Indicator Cards—W. Trinks, Mar., 1914, p. 18.

Design and Construction.

Power House Design for Economy—Alexander Dow, July, 1917, p. 323.

Novel Ejector Type of Power Plant Stack—A. M. DeBelis, Sept., 1915, p. 874.

Adaptation of inspirator principle to stack which from its shape is denoted the "Vase" stack. Successful operation in France shows merits of scheme.

Problems in Power House Construction—H. H. Esselstyn, May, 1915, p. 551.

Meeting and overcoming site difficulties in building heavy structure. Use of ice as datum plane for making test borings. Extending transportation facilities.

Boiler Shop: Slotting Flanges for Close Bends; Using Blueprints in Foundation Placing. Dec., 1915, p. 1,103.

Blast Furnace and Steel Mill Power Plants. June, 1917, p. 285.

Prime Movers.

Turbo Generator Installation Discussions—D. S. Jacobus, July, 1917, p. 326.

Installation of Large Turbo Generator—R. H. Rice, July, 1917, p. 315.

Specifications for four-furnace blast furnace plant. Comparison of gas engine and steam turbine plant. Segregated gas-electric and steam turbine electric stations.

Gas Engines at Blast Furnaces and Steel Plant. July, 1913, p. 14.

Distribution of Heat in Gas Engine Cylinder. Nov., 1915, p. 1,018.

Corrosion of Gas Engine Piston Rods. June, 1915, p. 600.

Recovery of Gas Engine Losses. Apr., 1915, p. 524.

Recording Load Meter for Steam, Gas and Oil Engines—F. F. Denk, Feb., 1914, p. 38.

Economics of Prime Movers for Blast Furnace and Steel Plants. Aug., 1913, p. 22.

Engines or Turbine. Apr., 1915, p. 442.

Straight Flow Steam Engine. Feb., 1915, p 164.

Steam Production.

Waste Heat Boilers for Open Hearth Furnaces—C. J. Bacon, June, 1915, p. 587. (See Open Hearth.)

Factors Governing the Cost of Power—George P. Roux, Sept., 1915, p. 879.

Relation of power plant to department of main business wherein it is considered a wheel within the wheel. Critical consideration of each item in power production.

Blast Furnace Gas in Steam Production—S. M. Marshall, Apr., 1915, p. 506.

Possibilities in bettered boiler efficiencies with more accurate ourner manipulation and discression of variation caused by furnace operation with new burner description.

Power Data in Steel Plant Economics—Franz Denk, M. E., Mar., 1915, p. 286.

Necessity of controlling gas production as well as steam and power generation in order to make a cost distribution fair to all departments. Ways and means for establishing control.

Testing Factors for Power Plant Units—Charles C. Lynde, Feb., 1915, p. 232.

Considerations of basis for efficiency calculations. Use of one boiler in battery as practical fuel calorimeter. Checking condensers and coaling towers.

A New Method of Firing Chain Grate Stokers. Feb., 1915, p. 221.

Description of features of American Sheet & Tin Plate Co.'s slow chain method of firing at Vandergrift, Pa. Interesting tests of efficiencies secured.

Suiting the Stoker Design to the Plant—T. A. Peebles, Feb., 1915, p. 222.

Consideration that must be weighed carefully in order to secure maximum efficiencies. Local conditions should affect choice of type. Inefficient yet smokeless operation sometimes obtained. Solutions of problems in plant remodeling.

Heat Transfer from Superheated Steam to Pipe Walls. Sept., 1916, p. 434.

Spraying Condenser Water. Aug., 1916, p. 394.

Checks on Control of Boiler Operation—Franz Denk, M. E., Feb., 1915, p. 158.

The Corrosion of Condenser Tubes. Mar., 1915, p. 293.

Central Station Steel Mill Service. July, 1915, p. 690.

Shooting Soot from Stacks. Sept., 1916, p 434.

Regarding Water Hammer. Apr., 1916, p. 184

Quirks and Kinks in Modern Boiler Shops—Charles C. Lynde, Sept., 1915, p. 867.

Rapid Flue Gas Analysis—W. Trinks, Aug., 1914, p. 36.

PRODUCTION EFFICIENCIES

Time Studies for Efficiency in Steel Mills—W. Trinks, Sept., 1916, p. 42.

Value of extension of recognized practice to the blast furnace and steel mill. Tying tonage rates and wage standards possible through time analysis.

Conditions Affecting Manufacture of Rails—Dr. J. S. Unger, June, 1916, p. 265.

Plea for lessened diversity of rail specifications and uniform railroad usage. Possibilities in size and dimensions of rails forecasted. Methods of investigating rails.

Purchasing Stock by Specification and Test—M. B. Smith, Dec., 1915, p. 1,086.

Laying down some fundamentals of great value in the securing of certain materials. Plan as given capable of adaption to needs of many manufacturing lines.

Testing of Scales for Material Weights—Eugene Motchman, May, 1915, p. 566.

Methods at the command of the field man for checking up equipment to verify shijments. Track and wagon-weighing devices often subjected to unfair loadings.

Common Ground for Office and Field Manufacture. Edward Godfrey, Mar., 1915, p. 335.

Pointing out a few of the ways wherein the two branches of the organization may co-operate to advantage. Illustrations of frequent causes of building failures.

Value of Concise Records to the Engineer—Ray S. Huey, Oct., 1916, p. 47.

Showing wherein the preservation of accurate and systematic records may be of value to the man in charge of work. Ways to gather this valuable data outlined.

Distributing Costs for Wire Manufacture—W. Trinks, Oct., 1916, p. 467.

Analyzing and distributing the entire list of factors entering into the total cost of a completed article made from steel. Preponderance of external factors shown.

Equipping Plant for Heavy Steel Work—Charles C. Lynde, Feb., 1917, p. 64.

Equipment layout for handling heavy stock through plant without hand labor. Combining overhead, wall, gantry and jib cranes for economical lifting.

Preparing Iron and Steel for Painting. Aug., 1916, p. 392.

Double-Bladed Hack Saw. May, 1916, p. 244.

Structural Shop: Improvising Transportation; Gas for Rivet-Heating on the Job. Nov., 1915, p. 1,061.

The Plant Preacher—R. J. Young, June, 1914, p. 40.

Distribution of Raw Material—J. N. Reese, June, 1914, p. 18.

Structural Shop: Color Identification for Different Jobs. Aug., 1915, p. 820.

Distribution of Equipment Wear and Tear—Nicholas T. Ficker, Dec., 1915, p. 1,088.

Spreading overhead expenses and wasting of equipment over several heads insures a more equitable charge upon each item. Machine unit and current variation ratios.

Riveting Kinks for Steel Car Construction—H. A. Hatfield, Dec., 1915, p. 1,084.

A practical man's sizing up of factors on the job most important for the production of acceptable work. Recommendations for positions of men and machinery.

Efficient Construction of Industrial Cars—Charles C. Lynde, Nov., 1915, p. 1,031.

Planning and executing production of varied lines with minimum of time and labor loss for changing of jobs. Feeder boys for preparing work enroute to assembling aisles.

Casting and Machining Under One Roof—Charles C. Lynde, Oct., 1915, p. 949.

Combining foundry and machine departments to eliminate lost motion between production of casting and completion of same. Lavor-saving kinks found advantageous in handling materials.

Items and Amounts Constituting Overhead—E. H. Fish, Sept., 1915, p. 882.

Typical shop as example of fair and equal distribution of factory expense Variables which may affect each portion of whole. Effectiveness of cost system as detector of faults.

Standardizing Accuracy in Machine Work—Aug., 1915, p. 801.

Methods, jigs and machines used in automobile building to insure absolute duplication of parts with minimum labor costs. Simplicity of equipment also obtained.

Plant Means for Pushing Quantity Output—Charles C. Lynde, Aug., 1915, p. 791.

Time and labor-saving schemes developed in bolt, nut, screw, rivet and washer plants for boosting production and holding down costs. Machinery vs. men in new installations.

Relation Between Production and Cost.—H. L. Gantt, Aug. 1915, p. 755.

Theory for distributing factory expense to care for periods of partial idleness without overburdening departments in operation. General cost factors.

Special Machines for Intricate Work. June, 1915, p. 640.

Adaptation of standard machine tools to

meet peculiar conditions of automobile crankcase production. Easing work and speeding up production.

Concentrating Units for Efficiency. Feb., 1915, p. 148.

Combination of plant equipment at Mansfield Sheet & Tin Plate Co.'s new mill. Saving in materials handling cost obtained. Lessened travel of stock during process of making.

To the Man Who Gets Out the Tonnage. Mar., 1913, p. 5.

Structural Shop: Gravity Operated Shop Trucks; Using Cranes as Scaffolds. Sept., 1915, p. 896.

Bolt, Nut, Screw, Rivet and Washer Shop: Mechanical Furnace Feed; Emptying Washer Bins; Blank Nut Storage. Oct., 1915, p. 977.

Bolt, Nut, Screw, Rivet and Washer Shop: Heat Treating Bolts; Reducing Belt Troubles. Nov., 1915, p. 1,060.

Bolt, Nut, Screw, Rivet and Washer Shop: Portable Material Handling Equipment; Finding Markets for Waste Material. Sept., 1915, p. 895.

Structural Shop: Giving the Time Clock a Chance; Tracking Across Wooden Floors; Keeping the Erection Floor Clean. Oct., 1915, p. 978.

The Efficiency Organization of Night Shifts—Harold C. White, Nov., 1915, p. 1,046.

Speeding Up Metal Stampings Production—Charles C. Lynde, Dec., 1915, p. 1,075.

Structural Shop: Collecting Scrap at Shears; Storing Special Plates. Dec., 1915, p. 1,104.

Economizing on Floor and Wall Space. Apr., 1915, p. 436.

Disposal of Waste Metals. Jan., 1917, p. 38.

Increasing Output from Men and Machines. Apr., 1915, p. 420.

Economical Reduction of Mill Scale. July, 1915, p. 690.

Items and Amounts Constituting Overhead—E. H. Fish, Aug., 1915, p. 807.

REFRACTORIES

Meeting the Demands of Fire Brick Users—C. S. Kinnison, May, 1916, p. 232.

Showing the modern methods of making fireclay refractories to stand the demands of service in the steel industry. Careful work and handling required to maintain quality.

Physical Analysis of Refractory Material—Cosmo Johns, Dec., 1917, p. 563.

Available materials not found wholly pure. High tenacity much desired property. Resistance to corrosion also important feature in selecting refractory materials. Other discussions.

The Texture of Fire Brick. Jan., 1917, p. 38.

Making Silica Brick for High Heat Service—Charles C. Lynde, Sept., 1915, p. 831.

Steps in the manufacture of refractories which must meet excessive temperature conditions. Plant designed to give most favorable course to production of high grade output.

Specifications for Fire Brick. Dec., 1916, p. 578.

Reclaiming Combustion Boats. Mar., 1915, p. 295.

Practical Methods for Testing Fire Brick—C. E. Nesbit and M. L. Bell, Aug., 1916, p. 369.

Concluding the presentation of refractory testing. Outlining conditions, apparatus and findings for various methods of determining brick qualities.

Practical Methods for Testing Fire Bricq—C. E. Nesbit and M. L. Bell, July, 1916, p. 331.

In testing refractories it is necessary that the operations be designed to similate the conditions of use as closely as possible. Each requirement imposes its own test.

Heat Resisting Clays and Their Behavior—J. L. Dickson, Mar., 1916, p. 119.

Influence of chemical composition on the behavior of fireclays and refractory brick under high heats. Limiting percentage of various materials in clay.

Factors Governing Selection of Fire Brick. Mar., 1916, p. 127.

Showing that there is no universal type of fire brick suitable for all the needs of modern blast furnace and steel plant. Recommendations for various uses.

Refractory Linings and Materials (No. 1)—J. W. Haulman, Apr., 1917, p. 159.

In which the author will take up seriation, the refractories used in steel plants, showing the methods for obtaining best results at each point where used.

Refractory Linings and Materials (No. 2)—J. W. Haulman, May, 1917, p. 197.

Showing where fireclay and silica are usable for certain linings. Technique and plan of lining Bessemer converters, cupolas and ladles for transporting their output.

Experimental Tests on Silica Brick—C. E. Nesbit and M. L. Bell, Sept., 1917, p. 409.

Study of the effect of degree of fineness of material and pressure. Defects increasing. Failure in actual service. Reducing failures to a minimum.

New Lava Crucible Stands 70 Heats. Aug., 1917, p. 375.

Heat Conductivity of Refractories. Apr., 1915, p. 429.

Investigations undertaken by German chemists to test safe temperature ranges with specific materials, using electric furnace heat for experiments.

Melting Points of Fire Brick and Clays. Jan., 1917, p. 36.

ROLLING MILL CONSTRUCTION AND ROLL PASS DESIGN

Drives.

Preservation of Belt and Rope Drives. Apr., 1915, p. 518.

Cotton Rope Power Transmission—J. Melville Allison, Aug., 1917, p. 354.

Comparison of cotton and manila rope. Consideration of centrifugal force, sheave diameter. Effect of over-roping. Example of steel mill installation. English and American practice.

Data on Rope Drive for Rolling Mills. Aug. 1917, p. 377.

Rope Drive Advantages. Sept., 1916, p. 425.

Value of Belt Tightener. Sept., 1916, p. 428.

Lubrication Requirements for Wire Rope—George R. Rowland, June, 1916, p. 286.

Showing how lack of appreciation of the inner workings of a wire rope and disregard of lubrication therefore may lead to grave friction losses and increased wear.

Involute and Cycloidal Gearings in Rolling Mill Drives. July, 1915, p. 665.

Application of two types of gear tooth to heavy work demanded of mill pinions. Wearing conditions of teeth and evidence of best shape as shown by wear of both kinds of tooth.

Need of Wire Rope Lubrication. May, 1917, p. 225.

Methods of Rolling.

Shovel Plates from Old Locomotive Tires—W. S. Standiford, June, 1917, p. 274.

Adjusting rolling mill equipment to handle scrapped tires. Preparing rolls for heavy-duty requirements in the mill. Problems of roll maintenance.

Electric Drive for Reversing Rolling Mills—Wilfred Sykes and David Hall, Aug., 1916, p. 375.

Answering some of the questions raised concerning the application of electric drives. Describing the construction found desirable for heavy drive.

Comparisons of Puppe and Gray Rolling. Mar., 1916, p. 125.

Characteristic beams rolled by both these mills analyzed and compared on production and utilization bases. Preponderance of evidence in favor of German mill.

American Rolling Mill Practice. July, 1913, p. 34.

Reinforcing Bars Rolled from Old Rails—W. S. Standiford, Dec., 1917, p. 560.

Describing the process of slitting and rerolling old rails into bars to be used for reinforcement. Consideration being given to practical methods of rolling and roll turning.

Power Requirements.

Performance of Uniflow Engine in Steel Mill. Oct., 1917, p. 473.

Roller Bearings for Steel Mill Cars—P. B. Lieberman, June, 1917, p. 264.

Interesting tests at large steel plants on yard rolling stock. Findings on train resistance secured with the aid of a dynamometer testing device.

Rolling Mill Power Requirements—F. Denk, Oct., 1917, p. 448.

Investigation of data obtained from tests on three high and reversing mills. Influence of various factors on power requirements. Curves showing test results.

Characteristics of Roller Bearings—P. B. Lieberman, Oct., 1917, p. 451.

Comparison of solid and flexible roller bearings. Tests showing deformation before and after load is applied. Chart showing relation of Brinnell number, scleroscope and tensile strength.

Central Station Power for Steel Mills—Joseph McKinley and Roy L. Baker, Oct., 1917, p. 441.

System of power distribution commonly used. Central station power supply more reliable than average steel mill plant. Inter-connecting of generating station.

Plate Mills for Rolling Sheared Plates—L. C. Biggert, Jr., Oct., 1917, p. 443.

Rolling Mill Power Requirements—F. Denk, Aug., 1917, p. 362.

Difficulties encountered in deviation of formulae. Interesting experiments showing flow of metal during rolling. Consideration of total mill load in continuous mill.

Rolling Formulae Resistance Calculations—W. Trinks, Oct., 1915, p. 899.

Limiting and fixing values and extent of coefficients used in present-day formulae for computing roll-train resistance. Characteristic examples and variations.

Features of Rolling Mill Reversing Engines—W. Trinks, June, 1916, p. 273.

Continuing the discussion of engine economy as secured by various changes in design. Influence of one-lever control striving toward perfection shown.

Suggestions for Correct Roll-Train Factors—W. Trinks, Nov., 1915, p. 983.

A revised formulae for calculating roll-train resistance which takes into consideration factors lumped in earlier types of expressions.

Power Requirements for Wire Drawing—Kenneth B. Lewis, Dec., 1915, p. 1,031.

A critical consideration of the factors to be met in the manufacture of wire and in drawing rods. Formulae and data curves for calculation.

Uniflow Steam Engine for Rod Mill Drive—Charles C. Lynde, Apr., 1917, p. 143.

Nordberg uniflow used as drive for roughing stands on continuous rod mill at Youngstown Sheet & Tube Co.'s Struthers plant. Electric drive on finishers.

Features of Rolling Mill Reversing Engines—W. Trinks, Apr., 1916, p. 179.
Inertia of reciprocating parts considered with its effect upon the rolling program. Need for care in speeding mills for long blooming passes shown.

Features of Rolling Mill Reversing Engines—W. Trinks, May. 1916, p. 210.
The problem of steam economy as secured by different weights and rotation ratios of rolling mill engines. Use of various efficiency factors to account for conditions.

Uniflow Engines on Rolling Mill Drives—W. Trinks, Dec., 1916, p. 558.
The uniflow engine compared with the electric drive for rolling mill work and for general power plant use in competition with the steam turbine. Fields for each defined.

Motive Power for Rolling Mill Engines. Aug., 1916, p. 361.
Discussing the applicability of electric drive for rolling mills. Design problems now before steam engine manufacturers will answer drive choice question.

Central Station Power for Steel Mills—Joseph McKinlety and Roy L. Baker. Oct., 1917, p. 441.
System of power distribution commonly used. Central station power supply more reliable than average steel mill plant. Inter-connecting of generating stations.

Factors in Roll Train Resistance—W. Trinks, Aug., 1915, p. 750.
Importance of thorough consideration of this condition in design and powering of roll stands. Inaptitude of present experimentally derived coefficients for all operation problems.

Rolling Mill Power Requirements. Jan., 1914, p. 26.

Features of Rolling Mill Reversing Engines—W. Trinks, Jan., 1916, p. 10.
The first part of a series to discuss the various types and modifications of the rolling mill prime mover with regard to operation characteristics as felt in the productions of steel and furtherance of economy.

Features of Rolling Mill Reversing Engines—W. Trinks, Feb., 1916, p. 66.
Slow biting and fast rolling as desirable features in the operation of a rolling mill power unit. Reasons why some types of steam engines fail to meet these points.

Features of Rolling Mill Reversing Engines—W. Trinks, Mar., 1916, p. 117.
The important question of securing evenness of turning moment in the steam-driven engine is here discussed with means for easily securing same.

Steam Economy of Mill Engines—H. Ortman, Aug., 1914, p. 32.

Tests on Electrically and Steam-Driven Blooming Mills. Nov., 1913, p. 48.

Steam Economy of Rolling Mill Reversing Engines. Oct., 1913, p. 18.

Power Required for Rolling Steel. Aug., 1913, p. 10.

Electrical Driving of Rolling Mills. Aug., 1914, p. 40.

Electric Drives for Reversing Mills—D. M. Retty, Oct., 1917, p. 464.

Purchased Power for Steel Mill Operation—C. S. Lankton, Oct., 1915, p. 923.
Possibilities of outside power courses as compared with complete generating and distributing units for powering rolling mill equipment.

Rolling Mill Power Requirements—F. Denk, Nov., 1917, p. 511.
Derivation of formulae giving the work necessary to roll steel. Data showing relation of pure work of rolling required and total work furnished.

Roll Mill Descriptions.

The Puppe Mill. Dec., 1915, p. 1,062.

Characteristics of Rolling Mill Couplings. Oct., 1915, p. 909.
Third portion of series taking up various kinds of couplings for steel mill heavy-duty. Features of types involving distortion of members of flexibility.

Puppe Universal Mill Sections. Apr., 1915, p. 518.

American Flexible Rolling Mill Coupling. Nov., 1915, p. 988.
Closing series of articles featuring various types of couplings used in transmitting large amounts of power under intermittent operation conditions.

Characteristics of Rolling Mill Couplings. Sept., 1915, p. 840.
Second paper of series treating on various kinds of couplings for heavy duty. Description of unique features of types based on original Hooke's joint or cross coupling.

A New Continuous-Running Two-High Mill. June, 1913, p. 20.

A Three-High Two-Pass Roughing Mill. Aug., 1915, p. 766.

A Tube-Forming Patent. Feb., 1915, p. 163.

Mill Controllers. Apr., 1915, p. 520.

Tandem Operation of Cold-Roll Mills—E. S. Lammers, Jr., Sept., 1916, p. 424.
Specialized control for tandem operation of cold-roll mills. Centralized location of units necessary for supervision of steel loops and speed regulation.

Development of Merchant Rolling Mills—Jerome R. George, June, 1915, p. 593.
Limitations of application of term "Merchant Mill" with historical consideration of improvement of equipment. Ways and means for obtaining economical operation.

German Mill Lubrication Problems. Aug., 1915, p. 768.

Conserving Roll Neck Grease. Feb., 1916, p. 96.

Repairing Crippled Rolls by Arc Welding. Dec., 1916, p. 578.

Operating Data on Electric Blooming Mill—E. S. Jeffries, Oct., 1916, p. 458.
First-hand operating figures on electric equipment for rolling mills with operating data to show operating instead of test results under varying loads.

The Puppe Universal Mill in Operation. Apr., 1915, p. 415.
Operation of new type two-high structural installation passes experimental stage, according to reports received in this country. Characteristics introduce new practice in flange design.

Roll-Neck Lubricants: Their Reclamation—William M. Davis, Dec., 1916, p. 564.
Heavy greases considered in regard to their application with emphasis on the hot-neck types of lubricant. Schemes for saving this lubricant and re-using it.

Gauging the Capacities of Blooming Mills—W. Trinks, May, 1917, p. 195.
Determining the capacity of the blooming mill in respect to other steel mill equipment. Curves showing capacity as related to elongation ratios. Influence of ingot weight.

Electric Reversing Blooming Mills—Ralph D. Nye, Dec., 1917, p. 566.
Operation of two electrical reversing mills compared. Data concerning tonnage and kw hours per ton. Complete description of units.

Bending and Spreading Forces in Rolls—W. Trinks, June, 1915, p. 581.
Formulae giving forces to be met in roll design with consideration of their effect on rolls, stands and production of shapes. Trustworthiness of data derived from experiments.

Internal Friction in Rolling Work—W. Trinks, Apr., 1915, p. 504.
Consideration of theoretical factors entering calculations of loss on spreading forces of rolling mill operation. Graphic results of former tests on various shapes.

Plate Mills for Rolling Sheared Plates—F. C. Biggert, Jr., Oct., 1917, p. 443.
Method of rolling. Types of mills. Production data. Heating furnace suggestions. Power requirements. Typical arrangements and layouts for general purpose mills,

Square Bar Equivalents for Straightening Sections. Apr., 1916, p. 184.
Table showing square bar equivalents.

Rolls for Edging Flat Bar Iron or Steel—W. S. Standiford, Sept., 1917, p. 397.
Edging rolls solving the problem of delay in waiting for roll orders. Design of rolls. Description of advantageous operation in rolling smooth product.

The Elements of Roll Pass Design—W. Trinks, June, 1917, p. 269.
How modifications of conditions affect supposedly positive rules. Fixing the limitations on possible reduction per pass. Action of materials under compression.

The Elements of Roll Pass Design—W. Trinks, July, 1917, p. 320.
Features influencing lateral spreading of steel in rolls with varying conditions of speed, temperature, reduction and shape of pass. Formulae considerations, showing limited range of applicability.

Elements of Roll Pass Design—W. Trinks, Sept., 1917, p. 400.
Discussion of seamless rolling gives evidence that great tension is permissible in white hot steel, free from flaws, if lateral contraction is not hindered.

Elements of Roll-Pass Design—W. Trinks, Nov., 1917, p. 518.
General rules for roll-pass design derived. Passes should be designed for maximum reduction possible under circumstances and to underfill rather than overfill.

Elements of Roll-Pass Design—W. Trinks, Dec., 1917, p. 555.
Rules presented in previous articles applied in roll investigation. Roll passes designed to fill or slightly underfill. Bending and torsion stresses in roll computed.

Roll Pass Design for Standard Rails—E. Standiford, Aug., 1917, p. 366.
Data and description of practice in several rail mills. Design of roughing intermediate and finishing passes. Hot sawing of rail lengths. Cooling and reheating for finishing passes.

Roll Design for Shrapnel and Shell Bars—W. S. Standiford, July, 1917, p. 312.
Box and edging passes for heavy drafts. Description of angle grooves, finishing and roughing rolls. Qualities of steel for rolls. Elements influencing accurateness of finished product.

Roll and Pass Layout for Rolling Specials—W. S. Standiford, Mar., 1916, p. 162.
Roll layouts and pass sequence for rolling special shapes to comply with munitions makers demands. Heating and manufacturing factors controlling product.

Solid Friction Presented by Roll Necks—W. Trinks, July, 1915, p. 666.
Ezplanation showing mechanical features involved in extremely rapid wear of roll necks and bearings. Unequal load distribution under varying drafts a factor.

Improved Rail Section. Aug., 1915, p. 768.

Position of Channel Passes Relative to Pitch Line.

Hardened Steel Rolls. Mar., 1916, p. 134.

Consideration in Roll Design. June, 1915, p. 600.

Rolling Mill Flanged Beam Sections—F. Denk, June, 1917, p. 271.
Theory and practice in the operation of Gray, Sack and Puppe mills. Stress problems involved. Flange characteristics contrasted.

Mill Designs for Rolling Flat-Flanged Beams—F. Denk, May, 1917, p. 202.
Summing up and concluding the series of articles describing the various types of rolling mills for forming flat-flanged work. Limitations of each mill and its field.

Rolling Wide-Flanged Beam Sections—F. Denk, July, 1917, p. 306.
Comparative fiber and bending stress calculations for Bethlehem, Differdingen, Sack and Puppe sections, assuming uniform load distribution.

Mill Design for Rolling Flat-Flanged Beams—F. Denk, Apr., 1917, p. 149.

Discussing method of rolling secured in the Puppe type of mill with gain in section shape secured thereby. Accurate adjustment of the rolls easily obtained through design.

Design of Mills for Flat-Flanged Beams—F. Denk, Dec., 1916, p. 562.
Part two of a discussion of different types of mills for this work. Grooved rolls for wide-flanged sections. Oblique method and its advantages and disadvantages.

Mill Designs for Rolling Flat-Flanged Beams F. Denk, Mar., 1917, p. 101.
Various types of American mills for turning out flat-flanged beams. Means adapted to avoid tilting and turning of beams and complications thereby introduced.

Design of Mills for Flat-Flanged Beams—F. Denk, Nov., 1916, p. 512.
The rolling of wide-flanged beams with parallel edges is becoming more and more of a necessity on account of the increasing field for such shapes. Various mills are described.

Mill Design for Rolling Flat-Flanged Beams —F. Denk, Feb., 1917, p. 61.
Rolling schedue for special shaped in the gray mill with sizes and shapes available with that equipment. Means for strengthening gray mill sections.

Design of Mills Rolling Flat-Flanged Beams —F. Denk, Jan., 1917, p. 7.
Continuing a discussion of the types and variations in mill design to give economical rolling of special beam shapes. Reasons for certain mill failures.

Investigation of Stresses in Mill Housings—F. D. Keller, Aug., 1917, p. 347.
Stresses in housings caused by spreading forces on the rolls. Harmful influence of sharp corners. Factors affecting breakage. Effect of shrinkage stresses.

Factors of Safety in Steel and Iron Parts—W. Trinks, Feb., 1915, p. 150.
Unanswered questions on actual values of stress and torsion rules as at present followed. How to make our machinery safer without making it heavier. Present-day formulae on angle and perforations questioned in the light of simple tests.

Clutch for Intermittent Service. Feb., 1915, p. 152.

Characteristics of American Hollow Rolling Mill Spindles. Aug., 1915, p. 745.
Various means developed for guarding against mill damage through breakage of spindles. Hollow spindles of safety types. Need for additional strength in early types shown.

Ball-Bearings and Rolling Mills. Mar., 1913, p. 14.

Detachable Rolling Mill Couplings. Apr., 1915, p. 499.
Types of power and stand connection devices which permit disconnecting one side without long shutdown. Ortman couplings and hollow spindles described.

Cutting Armor Plate. Dec., 1916, p. 578.

When a Roll Chills. Jan., 1916, p. 46.

Theory of Rolling.

Discussion of Rail Failure—A. W. Heinle, Sept., 1916, p. 420.

Spreading Forces in Rolling Mills—W. Trinks, Apr., 1915, p. 422.
Consideration of the resistance of material to compression a factor in the rolling process. Further data on laws of deformation as developed by research on experimental mill.

Rolling Cause of Rail Failure in Service—Dr. P. H. Dudley, Aug., 1916, p. 417.
Findings from investigation conducted by railroad to determine basic causes for rail failures. Two types of failure defined and listed causatively.

Investigation of Plastic Flow Phenomena—W. Trinks, Aug., 1916, p. 362.
Points of similarity between plastic flow of clay and that of steel. Comparative results from government investigation bear out experimental quantities.

On Deformation Limit of Plastic Materials. May, 1916, p. 205.
Limiting the blame for cracking and fracturing of steel under rolling and forging. Showing the mechanical factors concerned in the disturbance of steel structure.

Rolling Formulae Volume Considerations—W. Trinks, Sept., 1915, p. 825.
In which is pointed out the fallacy of the formulae based entirely upon the displaced volume theory. Development of rational expression for use with rolling work.

New Theories on Hot Mill Deformations Obtained by Experimental Rolling—W. Trinks, Mar., 1915, p. 276.
Variation of flow with draft in the rolling of steel. Illumination experiment in the rolling of lead suggest amendments in established hypothesis on resistance of plastic materials under varying pressures. Action of bar in actual test contrasted with friction pyramid theory.

Influence of Cooling on Service of Rails—Dr. P. H. Dudley, Jan., 1917, p. 28.
Addenda to the report published in the September, 1916, issue under the title. "Rolling cause of rail failure in service." Showing the influence of the cooling bed and rail placing.

Chances of Structure Caused by Cold Rolling Steel. Aug., 1913, p. 8.

Speed Difference between Steel and Rolls. Nov., 1913, p. 16.

Finishing Temperatures of Rails. Mar., 1915, p. 294.

SLAGS

Cement.

Utilization of Blast Furnace Slags. Jan., 1916, p. 44.

British Cement Specifications. May, 1915, p. 570.

Comment and Discussion from the Reader's Angle Concerning the "Ghost Lines" question. May, 1916, p. 206.

Economies in Bulk Handling of Cement—H. M. Capron, Mar., 1915, p. 338.
Factors which determine advisability of carload loading instead of use of customary sacked product. Reduction of loss possible with good equipment.

Blast Furnace Slag Cements. Jan., 1917, p. 36.

Kinds and Character.

Alumina as a Component of Blast Furnace Slag—W. G. Imhoff, June, 1917, p. 261.
Its relation to other slag components and the practical interpretation of slag peculiarities which are attributed to alumina. Effect on furnace gases.

Sulphur as a Component of Furnace Slag—W. G. Imhoff, Aug., 1917, p. 358.
Free and sublimated sulphur. Causes of high sulphur iron. Relation to various furnace conditions, such as hearth temperature. Fusion zone and furnace driving. Effect on slags.

Sulphur as a Component of Furnace Slag—W. G. Imhoff, July, 1917, p. 308.
The effect of combined sulphur on furnace driving. Relation to furnace gas. Importance in connection with lime. Calculations considering varying furnace conditions.

Lime as a Component of Furnace Slag—W. G. Imhoff, Sept., 1917, p. 411.
Classification of lime. Features distinguishing lime-hot furnace from lime-cold furnace. Properties of cinder indication of furnace condition.

Conditions and Causes of Iron in Slags (3)—W. G. Imhoff, Oct., 1916, p. 455.
Iron as silicate: extremes of. Furnace conditions, relation to hearth temperature: condition of stock in the hearth and quickest means of restoring normal furnace conditions.

Some Causes of Colors in Furnace Slags—W. G. Imhoff, Feb., 1917, p. 58.
Influence of temperature volume and chemical composition on slag colors. Relation of color to chemical components. Practical value of color to furnace conditions.

Types of Different Blast Furnace Slags—W. G. Imhoff, Mar., 1917, p. 113.
Effect of change of burden influence of cold air; Relation that hearth temperature bears to different slag types; development of slag series.

Conditions and Causes of Iron in Slags (2)—W. G. Imhoff, Sept., 1916, p. 413.
Iron as iron oxide. Its development and significance as a slag component. Its relation to temperature, black slags and chemical analysis.

Silica as a Component of Blast Furnace Slag —W. G. Imhoff, Apr., 1917, p. 155.
Slag characteristics due to silica. Relation to the driving of the furnace. Its effect upon sulphur and other slag components. Relation of silica to slag volume and hearth temperature.

Characteristics of Electric Furnace Slags—W. G. Imhoff, May, 1917, p. 204.
The function of the first or oxidizing slag. The impurities of the steel which are removed by this slag. Its characteristics and how to secure them.

Conditions and Causes of Iron in Slags—W. G. Imhoff, Aug., 1916, p. 359.
Physical and chemical states of iron in slags. Relations to burdening stock and furnace conditions. Losses and recovery of iron from cinder.

Viscosity Testing of Blast Furnace Slags. June, 1916, p. 281.
Apparatus designed by Bureau of Mines for testing and comparing viscosity. Characteristics of various slags under conditions similar to those encountered in active stacks.

Sulphur as a Component of Furnace Slag—W. G. Imhoff, July, 1917, p. 308.
Effect of combined sulphur on furnace driving. Relation to furnace gas. Importance in connection with lime. Calculations considering varying furnace conditions.

Slag Determination. Aug., 1914, p. 5.

Production.

Slag Handling for Economical Utilization—Charles C. Lynde, Jan., 1916, p. 1.
Two methods at one plant for the recovery of the slag and cinder in a condition readily unable for road making, cement manufacture and other industrial uses. Chain beds and steam shovels as recovery means.

Saving on Slag Through Efficient Crushing—H. V. Shiefer, Nov., 1916, p 499.
Saving handling costs and making profit on what is usually considered a drawback to successful blast furnace operation. Mechanically operated apparatus used.

Double Skimming of Slag. Mar., 1916, p. 134.

Impregnation of Fuel with Slag. Mar., 1916, p. 138.

Handling Ladle Slag. Mar., 1915, p. 295.

STEELS

Production.

Production of Low Carbon Electric Steel—A. S. Hellstrom, Aug., 1917, p. 392.

Recent Electrical Steel Purification Proces. Apr., 1915, p. 436.

High Speed Steel Alloy by New Process. Nov., 1916, p. 532.

Wrought Iron's Relation to Ferrous Metals —D. F. Manice, Jan., 1916, p. 82.
Giving a review of the historical aspect of the manufacture of wrought iron with inference on its influence on the production of other ferrous metals.

Metaloid Removal from Metal Washing—Edward L. Ford, Feb., 1917, p. 56.

Discussing "Washed metal in special steel making," by Henry D. Hibbard in the primary number and giving Brier Hill process and results at that plant.

Making and Buying Sheet and Strip Stock—F. Walter Guibert, May, 1917, p. 218.

Cold rolled steel as considered from the point of view of the maker and user. Kinds of special stock oftenest specified. Processes necessary for manufacturing each.

Causes and Effects of Seams in Steel—W. D. Mainwaring, Sept., 1913, p. 10.

Commercial Development of Alloy Steel—Edward D. Rogers, Nov., 1915, p. 1,042.

Historical and practical viewpoints regarding the use of alloy steels with emphasis upon those produced from the usual steelmaking equipment rather than in crucibles.

Production of Homogeneous Steel—Edward F. Keeney, July, 1915. p. 675.

Factors governing manufacture of commercial amounts of sound, unblemished steel. Segregation and blowholes practically eliminated. Insulating taps used.

Washed Metal in Special Steel Making—Henry D. Hibbard. Jan.. 1917. p. 12.

Washed metal as used by the Brier Hill Company to give specially purified product for making higher grades of product. Operation and features of washing equipment.

Properties.

Compressive Density Changes in Mild Steels. Aug., 1915, p. 770.

Strength and Inner Structure of Mild Steel—Prof. W. E. Dalby, June, 1917, p. 277.

Study of cementite and pearlitie combinations and their evolution during heat treatment. Action under cooling processes must be traced in preparing absolute data.

Etching Re-agents. Apr., 1915, p. 520.

Definition of Hardness—A. E. Tutton, Feb., 1917, p. 70.

Internal Friction of Metals. Oct., 1916, p. 490.

Growth of Cast Iron Parts. Sept., 1916, p. 434.

Molten Zinc as Re-agent for Microscopic Etching of Iron and Steel—Jesse L. Jones, July, 1915, p. 667.

Determination of Alloys in Steels. Apr., 1915, p. 522.

Characteristic Edges of Pig Iron Samples—W. G. Imhoff, Jan., 1917, p. 9.

The practical furnace man's method of judging analysis at casting. Relation the iron bears to furnace conditions. Courses which give individuality to samples.

Peculiar Appearance of Some Sawn Bars. Apr., 1916, p. 157.

Unusual structure showing on the sawn sections of bars leads to determination of mechanical or chemical causes. Vibration of saw responsible.

Permissible Sulphur in Steel—J. Shownawa, Sept., 1916, p. 421.

The Effect of Sulphur in Rivet Steel—Dr. J. S. Unger, July, 1916, p. 333.

Showing how the working and physical properties of rivet steel are affected by increasing amounts of sulphur. Best of evidence that steel may safely contain a much higher sulphur content than that usually specified for open hearth steel.

Chemistry of Oxygen's Strengthening Iron—W. M. Johnson, Mar., 1916, p. 116.

A discussion of J. B. Johnson, Jr.'s findings with regard to oxygen as a strengthening factor in iron. Chemical form of such effect set forth.

Heat and Carbon Steel Chemical Nature—Edward D. Campbell, Jan., 1916, p. 18.

Influence of heat treatment on the specific resistance and chemical composition of carbon steels. A tracing of the relations between these characteristics of the material.

Characteristics of Spelter. Oct., 1916, p. 490.

Tests.

Torque and Work of Acceleration—Philip Hoffman. Aug., 1917, p. 37.

Impact Tests and Their Relations to Others—Howard J. Stagg, Jr., May, 1917, p. 209.

Comparison of the results obtained from various types of machines for testing resistance to impart torsion and other stresses of steels of various analyses. Tabular stress relation.

Data for Shearing Steel and Other Metal—W. Trinks, Mar., 1917, p. 95.

Tests to determine the equivalent cutting capacity of given shears on various kinds of stock. Curve presented obtained from series of practical shearings.

Electric Steel Tests. Oct., 1916, p. 492.

Impact Coefficients for Girders. May, 1915, p. 569.

Use of X-Ray for Testing Steel. Apr., 1915, P. 438.

Micrographic Studies on Copper, Iron and Steel. Feb., 1917, p. 74.

Detecting Steel in Wrought Iron Pipe. June, 1916, p. 298.

A Method for Testing Sheet Steel. Nov., 1916, p. 530.

TEMPERATURE MEASUREMENTS

Recent Progress in Pyrometer Design. June, 1915, p. 648.

Adaptability of various types of instrument to measurement of high temperatures under severe operation conditions. Degree of accuracy to be expected.

An Optical Pyrometer for Works Use. Aug., 1917, p. 388.

Temperature Measurements in Bessemer Iron Open Hearth Practice. May, 1917, p. 225.

Furnace for Thermal Analysis. Apr., 1915, p. 524.

Recent Progress in Pyrometer Design. June, 1915, p. 648.

Heat Meauring Limits. Apr., 1917, p. 174.

Pyrometry in Blast Furnace Practice—S. H. Stupakoff, June, 1914, p. 42.

Iron Thermo Couples. June, 1915, p. 598.

Bessemer and Open Hearth Temperature Gaging—George K. Burgess, Mar., 1917, p. 117.